Comparative Studies on the Currency Board Regime and its Impact on Hong Kong’s Economy

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Abstract

My thesis attempts to search evidence on the performance of the currency board regime and its impact on Hong Kong’s economy. Three sets of related questions have been set up and carefully investigated in my empirical models.

Chapter 2 investigates output growth and inflation rate in order to compare the historical performance of free-floating and currency board regimes for Hong Kong. I apply some advanced econometrics tools to identify my structural VAR models and offer appropriate analysis. My first empirical model suggests that output returns to a steady state much faster in a flexible exchange rate regime than in a fixed exchange rate regime after an aggregate demand shock. My evidence offers an essential answer to the question on why the recovering process of Hong Kong from the Asian financial crisis lasted longer compared with the other Asian countries with a flexible exchange rate regime. Furthermore, my counter-factual analysis suggests that a free-floating regime may generate much smaller output variance in Hong Kong and deliver higher output and price levels to Hong Kong.

Chapter 3 investigates the currency board regime from 1984 to 2007, by considering some important variables which have significant impacts on Hong Kong’s economy. For instance my empirical models attempt to examine the economic relationships with the US economy under the currency board regime and the close economic relationships with China under a Closer Economic Partnership Agreement with Mainland China. My models emphasises the importance of entrepot trade for Hong Kong’s economy. Evidence shows that those exogenous variables have significant impacts on Hong Kong’s economy, and they are one of the important factors when considering the choice of exchange rate regimes. My empirical evidence indicates some new findings which contradict existing studies which conclude that the Chinese economy is much less significant than the US economy in explaining Hong Kong’s output variance.
Chapter 4 examines the real effective exchange rate misalignment of the two economies, Hong Kong and Singapore, and offers new policy implications on the choice of exchange rate regimes. Entrepot trades are essential to both economies. While the literature has paid little attention to such an important character and shown evidence of larger scale REER misalignment in Hong Kong compared with Singapore, my model reveals that including such an important variable has remarkably improved the model and offered strikingly different conclusions. I have applied Vector Error Correction Modelling and the Johansson Method in identifying the empirical models. Evidence suggests that Hong Kong performs well in terms of small real exchange rate misalignment even under its currency broad regime.

My thesis indicates that although there are limitations in the currency broad regime in terms of relatively slow recovery from external demand shocks and relatively larger output variance, the regime is still a preferable choice for Hong Kong, especially when we consider the close economic link with Mainland China and the United States. Moreover, there is no evidence in my models to suggest that the real exchange rate misalignment was significantly larger in the case of Hong Kong’s currency board regime.
Declaration

NAME: ..........................................................    PROGRAM: ..................................................

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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Chapter 1
Introduction

Hong Kong’s economy has enjoyed fast and sustainable growth over the past fourty years and became one of major industrialised regions in Asia. During these years, Hong Kong experienced some major changes in its monetary policy regimes. From November 1974 to October 1983, the authority adopted a free-floating exchange rate regime, while after October 1983 the authority implemented a currency board regime in which the exchange rate of the Hong Kong dollar was fixed at the rate of 7.8 Hong Kong dollars per US dollar. As a fixed exchange rate regime, the Currency Board is also called Linked Exchange Rate System (LERS).

When examining the contemporary economy of Hong Kong, one can find two unique characteristics. One is the currency board regime, in which the Hong Kong Monetary Authority (HKMA) only targets a fixed exchange rate for a stable economic environment and international confidence. The authority pays a cost of giving up the autonomy of controlling a short term interest rate to encourage output growth and maintain low inflation. Another is the laissez-faire policy, in which the government attempts to minimise the government’s intervention on the economy. Hong Kong has been maintaining a top ranking in terms of economic freedom in the last three decades. For instance, Hong Kong ranks number one in the 2009 Index of Economic Freedom provided by the Heritage Foundation and Wall Street Journal.

While the currency board regime has been successfully implemented for more than twenty years, the regime itself has been controversial at times, especially in periods of economic downturn. On one hand the fixed exchange rate regime can help to strengthen its role as an international finance and service centre; on the other hand, during the Asian financial crises period, the regime could not perform satisfactorily in mitigating the fluctuation of output and price level compared to other monetary policy regimes with a flexible exchange rate.
1.1 A brief review of Hong Kong’s economy under the currency board regime

- A unique small open economy

Hong Kong’s economy relies heavily on the foreign sectors, such as international finance center and international trade and logistic centres. The total value of the foreign trade in goods and services is equivalent to over 2.5 times Hong Kong’s annual GDP. As a regional trade centre, over 95% of Hong Kong’s exports are actually re-exports of merchandised goods from Mainland China to the rest of the world according to the figures in 2007. On the other hand, Hong Kong has a completely open capital account and international capital movements are subject to few restrictions. The volatilities in the world finance markets can easily create a substantial financial shock for Hong Kong. The economy requires a stable exchange rate environment to strengthen international investors’ confidence. The currency board regime was introduced in 1983 for this reason.

- The advantage of the Currency Board arrangements

The advantage of a currency board can be seen in encouraging foreign investment. The currency board regime creates a stable foreign exchange environment for Hong Kong which can bring confidence to foreign investors. When China opened its door to the world and became one of the major manufacturing centres in the past three decades, Hong Kong played an essential role in connecting China with the rest of the world, and became a major financial, logistical and professional service centre for China. As a small open economy, exchange rate stability is a crucial concern. Many foreign investors choose Hong Kong as their first stop when they prepare to invest in Mainland China. Although Hong Kong faced direct competition from Shanghai in the finance and foreign trade sector in the past decade, it continued to grow in all major sectors. Hong Kong’s advantage can be seen in all sub-categories of the Index of Economic Freedom, such as business freedom, investment freedom, trade freedom, financial freedom, fiscal freedom, property rights, government size, freedom from corruption, monetary freedom and labor freedom. Most of its achievement in those categories can be attributed to the currency board regime and laissez-faire policy.

- The disadvantages of the Currency Board arrangements

Exchange rate stability does not necessarily bring a favourable macro economic environment to Hong Kong. First, the Hong Kong Monetary Authority (HKMA) gives up
one of its major policy tools (interest rate), which can stabilise output and inflation when necessary. Compared with a flexible exchange rate regime, under which a central bank sets the monetary policy objective targeting inflation and output growth, the Currency Board only targets the stability of the exchange rate. When Hong Kong’s economic cycle is different from the US economic cycle, Hong Kong’s interest rate, which moves closely with the US dollar counterparts, fails to provide the best response to the local economy. For instance, the US economy is overheated and the Federal Reserve focuses on controlling the inflation, while Hong Kong’s economy is on the recovery from a recession, the high local interest rate induced by the Currency Board will slow down the recovery of the economy, and cause higher unemployment and deflation. This was the case when the Asian financial crisis hit the region and brought a painful experience to Hong Kong.

Moreover, an economy with a fixed exchange rate regime recovers relatively slowly from a regional shock. An economy with a flexible exchange rate can regain a competitive advantage by depreciating its currency and recover from the recession in a relatively short period, while an economy with currency board arrangements could only deflate the price and wage level to regain competitive advantage. There is some degree of rigidity among prices and wages which may take years to adjust to a suitable level. Consequently, the deflation procedure is relatively long and painful. As a matter of fact, it took a relatively longer time for Hong Kong to recover from the recession after the Asia finance crisis in the 1990s, especial when we examine the long deflation period from 1998 to 2003 in Hong Kong.

I compare output growth and CPI index data for Hong Kong and Singapore in the following section. Source of the data is from the Censors and Statistics Department of Hong Kong and the Singapore Statistics Department.

First, I compare the economic growth rates for Hong Kong and Singapore in Figure 1-1. Although both economies share a similar business cycle, the figure indicates that Singapore recovered to positive growth in 1999Q2 and maintained considerable economic growth (around 10%) until 2000Q4, while Hong Kong’s recovery was found in 1999Q4 and did not last as long as Singapore experienced. Moreover, both economies suffered from the 2001Q1-2002Q2 economic downturns originated from the burst of the dot.com bubble. Although Singapore suffered a more server hard-hit as a major IT technology centre, Singapore also recovered two quarters earlier than Hong Kong (in 2002Q2).
Second, I examine the consumer price index for both economies in Figures 1-2 and 1-3. These two figures indicate two different situations. From 1998 to 2004, Hong Kong suffered from a seven year deflation period, which is rare compared to the other economies. Figure 1-3 illustrates that Singapore did not suffer a similar deflation situation.

**Figure 1-2 Hong Kong CPI index**  
*(Year 2000=100)*

**Figure 1-3 Singapore CPI index**  
*(Year 2000=100)*

*Source of data: Hong Kong C&S Department.*

*Source of data: Datastream.*
Figure 1-4 denotes the hard-hit property market in Hong Kong from 1998-2003. The market experienced a six-year downturn and only recovered in 2003Q3. The figure indicates that many households experienced significant reductions in wealth and consequently domestic consumption was weak during the recession period.

**Figure 1-4 Hong Kong Private Retail House Index (Year 1999=100)**

NOTE:
This figure is included on page 5 of the print copy of the thesis held in the University of Adelaide Library.

Source of data: Hong Kong C&S Department.

- Flexibility of Hong Kong’s economy

The currency board regime, on one hand, provides a stable exchange environment, but on the other hand restricts the ability of the authority to mitigate shocks to the economy by adjusting the interest rate. Therefore, it requires that the economy itself has a flexible structure, which can recover from shocks quickly. Prices and wages need to be adjusted quickly after shocks. Although Hong Kong’s economy has some degree of flexibility, these conditions are difficult to satisfy in reality. Price levels, especially the prices for nontradable goods and services, could not adjust quickly. Stickiness of price still exists even in a flexible economy. Wages are relatively difficult to decrease, since work agreements are set for the next few years, and it is not easy for the majority of employees who have all their expenses fixed to accept a reduced wage. Figure 1-2 & 1-4 reveal the slow adjustment of consumer price index and private property price index from 1998 to 2003 after the Asian financial crisis.

However, there is some favourable improvement of the economy’s flexibility since 2003, when the Hong Kong SAR government signed, in stages, the Closer Economic Partnership Agreement with the central government in Mainland China. In the past twenty years, Hong Kong’s economy has been highly integrated with the Chinese economy, and such integration helps to improve the economy’s flexibility. While Mainland China is developing into a global manufacturing centre, Hong Kong has specialised in finance, trade and logistics. Labour and capital movements between the two economies are encouraged.
For example, professional workers from Hong Kong such as lawyers, accountants and medical practitioners can practice in Mainland China with their professional qualification recognised. Educated or skilled personnel from Mainland China are encouraged to migrate to Hong Kong. Moreover, external workers will be introduced whenever labour shortage occurs in a variety of sectors. When there is an external shock to Hong Kong’s economy, the Central Government can encourage more resource inflow to Hong Kong. Under the Closer Economic Partnership Agreement, more resources have flowed to Hong Kong from China and strengthened the economy. For example, more tourists are encouraged to visit Hong Kong, Hong Kong banking sectors are allowed to carry out business on the Chinese Yuan, and products from Hong Kong are allowed to enter the mainland market without any custom tariff. In general, capital and labour mobility between the two regions helps to create a more robust economy, which is a basic requirement for a currency board regime, in addition to the price and wage flexibility.

1.2 The history of Hong Kong’s currency arrangements

Hong Kong implemented a silver standard from the nineteenth century to the first three decades of the twentieth century. In 1934, the silver standard could not be maintained because of the huge outflow of silver. In 1935, a currency board regime against the British Pound was introduced and an exchange fund was set up. Note issuing banks were required to purchase Certificates of Indebtedness from the exchange fund with Pound Sterling at a fixed rate of sixteen Hong Kong dollars to one British Pound, when they were issuing bank notes. This regime lasted almost three decades, except for a four-year break when Hong Kong was invaded by Japan during the Second World War. In July 1972 the Pound Sterling suffered a significant devaluation against the US dollar and the currency board regime against the Pound was abandoned. The following regime was a peg to the US dollar at a rate within an intervention band. However, this regime only had a short life of two years with the depreciation of US dollar and capital inflow to Hong Kong. Finally the government decided to introduce a free-floating regime and abandon the currency board system.

During the free-floating period, from 1974 to 1983, note-issuing banks were required to back their bank note with liquid assets denominated in Hong Kong dollars. However, such a system could not successfully control the money supply, since these banks could borrow foreign currency to access the required liquid asset ratio. As a result, Hong Kong experienced a much more volatile money supply in the free-floating period. In 1978, the
government transferred the fiscal surplus into the exchange fund to strengthen the exchange rate regime. Under the free-floating regime, there were two extremes in the exchange rate. Prior to 1977, the exchange rate of the Hong Kong dollar was fairly strong, but after that year the dollar suffered from significant depreciation pressure for several reasons. One was the imbalance of international trade, another was a fast-growing money supply with a rapid increase of bank credit, and the other most essential one was the crisis of confidence in Hong Kong’s economy, during the time when China and Britain began talks on the handover of Hong Kong. The negotiation between the two nations created substantial shocks: the stock market and property market collapsed. There were runs on small banks and noticeable depreciation in the exchange rate. In order to defend the Hong Kong dollar and strengthen the economy, the government had no choice but to implement the currency board regime again, in which the exchange rate was fixed at 7.8 Hong Kong dollars to one US dollar. Now, note issuing banks are required to purchase Certificates of Indebtedness with US dollars from the exchange fund, whenever they issue notes. The Currency board regime has been implemented in Hong Kong since 1983, and the regime survived the Asian financial crises in 1997 and 1998.

**Table 1-1 Exchange rate regimes for the Hong Kong dollar**

| Source: Hong Kong’s Linked Exchange Rate System, HKMA publications. |
1.3 The mechanism behind the currency board

I summarise the mechanism according to Yam (1998) as follows.

1.3.1 Features of a modern day currency board arrangement:

- Bank notes in Hong Kong are indirectly backed by the US dollar. Whenever the three major commercial banks issue bank notes, they are required to buy an equivalent value of the Certificates for Indebtedness (CIs) with US dollars from the Hong Kong Monetary Authority (HKMA) to back the bank note issuing.
- Commercial banks’ aggregate balances at the Currency Board are also backed by the US dollar. Real Time Gross Settlement (RTGS) was established in December 1996 and the Aggregate Balance at the same time was put directly on the balance sheet of the Currency Board.
- Exchange fund bills and notes are a part of the monetary base now. On the other hand, the intra-day Repurchase Agreement (Repo) of the RTGS and Liquidity Arrangement Facility (LAF), however restrictive, allow transferability into the Aggregate Balance.

All these measures create a solid foundation for the currency board regime, which guarantees the convertibility rate fixed at 7.8 Hong Kong dollars per US dollar. Consequently, these measures help to eliminate speculations of revaluation of the Hong Kong dollar in the foreseeable future.

1.3.2 Mechanism of setting the interest rate

Under the currency board arrangement, the exchange rate is fixed and the interest rate will fluctuate when there is inflow or outflow of funds in the foreign exchange market. The money base will increase when the US dollar is sold to the Currency Board for Hong Kong dollars (capital inflow). Conversely, when the US dollar is bought from the Currency Board with Hong Kong dollars, the money base will be reduced. The injecting or redrawing of money base from the monetary system will force the local interest to fall or rise respectively. Such interest rate movement will automatically counteract the capital movement, and stabilise the exchange rate of the Hong Kong dollar.
Under the mechanism shown in Figure 1-5, the Hong Kong interest rate will keep very close to the US interest rate. According to the covered interest rate parity theory, when the risk of exchange rate loss is covered, the local interest rate will be equal to the foreign interest rate. Suppose the Hong Kong interest rate is higher than the US interest rate. Under the currency board regime, foreign investors will convert their US dollars to Hong Kong dollars for a higher interest rate return as they will not suffer any potential loss in the exchange market. The capital inflow will actually increase the money base in Hong Kong, and consequently the increase in money supply will push down the local interest rate. Such a capital movement will not stop until the local interest rate is at the same level as the US interest rate.

Source: Hong Kong’s Linked Exchange Rate System, HKMA publications
1.4 Methodology to model Hong Kong’s economy under different exchange rate regimes

After I introduce the background to Hong Kong’s economy in sections 1.1 to 1.4, I am supposed to lay out the general methodology applied in my research. My general aim is to examine Hong Kong’s macro economic variables under different exchange rate regimes, analyse the characteristics of different regimes and improve our knowledge of Hong Kong’s economy.

I searched the literature, and found a series of papers which have the same research interests and develop a reliable method to compare economies under different exchange rate regimes. Bayoumi & Eichengreen (1994) analyse the comparative macro economic performance of the Bretton Woods System of pegged exchange rates and the post-Bretton Woods float in small empirical models. These models examine the relationship between output growth and inflation, and provide a reliable interpretation consistent with the aggregate-supply and aggregate-demand framework. In particular, the authors inquire into the relative importance of aggregate-supply and aggregate demand disturbances in periods of fixed and floating exchange rate regimes. They examine whether the impact effect of disturbances and the economy’s adjustment to them differs according to the exchange rate regime.

The empirical model in Bayoumi & Eichengreen (1994) is called structural vector auto regression (SVAR) model, which was initiated by Sims (1972, 1980) and became one of the popular research tools in macro and monetary economics. Many economists contributed to the development of the method and it became a robust method in empirical modelling. Moreover, I also searched the literature applying the SVAR method to study Hong Kong’s economy. Kwan & Lui (1995) follow Bayoumi and Eichengreen’s method to model Hong Kong’s output growth and inflation in order to compare the free-floating and flexible exchange rate regimes. I will use Kwan and Lui’s paper as a major reference, point out their model’s limitation, and offer a more robust model. By comparing my empirical results with Kwan and Lui’s paper, I reveal the importance of my model specification and illustrate new evidence found on the economy. Some of my empirical evidence suggests different conclusions about the economy under flexible and fixed exchange rate regimes; therefore I offer the policy-maker valuable policy reference. Moreover, I also apply some new analytical tools such as sacrifice ratio analysis in my empirical study. Furthermore, I extend the empirical model to include exogenous variables which play a significant role on Hong Kong’s economy. I analyse the important impact of major trading partners on Hong
Kong’s economy, such as Mainland China and the United States. Last but not least, I investigate the real effective exchange rate (REER) under different exchange rate regimes by comparing empirical models on the economy of Hong Kong and Singapore. I analyse the misalignment of REER of the two economies.

1.5 Lists of research questions and research layout

I am interested in the following three sets of questions which have not yet been satisfactorily addressed in the literature. Evidence is found from the following empirical models in order to offer satisfactory answers and provide insightful policy implications. Furthermore, I illustrate the contributions of my study as follows.

First set of questions:
(a) Is there evidence from Hong Kong to suggest that the effect of aggregate demand shock on output is smaller under flexible exchange rates than under fixed exchange rate regimes?
(b) Why did the recovery process of Hong Kong from the Asian financial crisis last longer compared with other Asian countries with a flexible exchange rate regime?
(c) Furthermore, from the historical evidence, which regime performed better in Hong Kong in terms of macro economy stability?

In Chapter two, following Bayoumi & Eichengreen (1994), Kwan & Lui (1995) and Cecchetti & Rich (2001), I choose output growth and the inflation rate as the endogenous variables to establish my empirical model. I identify the parameters of unrestricted VAR models on data from both the free-floating period and currency board periods. I apply the Banchard & Quah restriction (also known as money neutrality in the long-run) as the extra restrictions to recover my structural parameters. Furthermore, I follow Ceccetti’s model to release the unitary assumption in the structural residual matrix. After I recover the parameters of the above two structural VAR models, I compute their impulses response functions, variance decompositions and sacrifice ratios. The sacrifice ratio analysis captures the cumulative output loss arising from a permanent reduction in inflation. I apply Runkle’s (1987) bootstrap method to calculate the 90% standard error of the impulse response function and confidence intervals of the sacrifice ratios. Comparing the SVAR models of different regimes in the above analyses, I discover evidence to answer research questions I(a) & I(b). Moreover, I do some counter-factorial analyses and attempt to answer my last research question. I investigate which regimes performed better in terms of macro stability in Hong Kong from a historical point of view.
I make contribution by writing Matlab codes to conduct structural VAR analysis, including impulse response functions with confident intervals, variance decomposition and sacrifice ratios. Furthermore, I contribute to the literature as follows: first, I provide evidence to show that my SVAR model is more robust in the model assumption compared to the Kwan & Lui model, in which the authors assume unit variance in the structural shocks. Second, I apply the sacrifice ratio analysis to Hong Kong’s economy, which has been ignored in the existing literature. Third, in my counter-factual analysis comparing the flexible and fixed exchange rate regimes, I find evidence that under free-floating regimes, the fluctuations of output growth have been noticeably reduced while the variations of inflation are marginally higher. My findings contradict Kwan and Lui’s findings, which conclude that currency board regimes generate smaller standard deviations in output growth and inflation. I analyse the limitation in Kwan and Lui’s model and justify my findings in Chapter two. All my analysis and findings are valuable references for the policy makers when considering the impact of the currency board regimes on Hong Kong.

Second set of questions:

(a) What are the major exogenous variables which transmit the impact of the US economy on Hong Kong? (b) What are the key exogenous variables which can capture the close economic relationship between Mainland China and the Hong Kong SAR? (c) Which of my two empirical models can better capture the impact of the external demand and supply on Hong Kong?

In Chapter three I carry out further studies on the currency board regime from 1984 to 2007. I examine the currency board regime in Hong Kong by adding some vital exogenous variables which have significant impacts on Hong Kong’s economy. The purpose of this chapter is to examine the economic relationships with the US economy under the currency board regime and the close economic relationships with China under a Closer Economic Partnership Agreement (CEPA) with the Central Government in China. As an international business, finance and service centre linking China with the rest of the world, trade activities are essential to Hong Kong’s economy. I use the trade-related data to extend the model of Chapter two. Evidence shows that those exogenous variables have significant impacts on Hong Kong’s economy, and they are one of the important factors when considering the choice of exchange rate regimes.

In this chapter, I provide a new way to model the impact of external trade on Hong Kong’s economy. I analyse the limitations of empirical models in Genberg et al (2006), and offer a more robust specification in which all the external variables are regarded as
exogenous. My empirical evidence suggests some new findings which are opposite to Genberg’s conclusion that the Chinese economy is less significant than the US economy in explaining Hong Kong’s output variance.

Moreover, my models analyse the bilateral trade data instead of foreign output growth data in order to capture the impact of external demand shifts. With the rapid development of the CEPA in the past five years, it was a growing interest to analyze the impact of such an economic stimulus agreement, especially the impact on the exchange rate regime choice of Hong Kong. However, limited research has so far been carried out as there are only limited observations for the period of CEPA. Chapter three overcomes this difficulty and fills the gap in literature.

Third set of questions:
(a) What are the major economic fundamental variables for small open economies such as Hong Kong and Singapore, which can explain the equilibrium behaviour path of the REER? (b) When comparing the two economies in terms of real exchange rate, which regime can create a stable macro environment in terms of lower degree of REER misalignment and encourage economic growth?

In Chapter four I focus on comparing the economies of Hong Kong and Singapore with different exchange rate regimes. Entrepot trade is very essential to Hong Kong’s and Singapore’s economies. While the literature has paid little attention to such an important character and shown evidence of larger scale REEF misalignment in Hong Kong compared with Singapore, my model illustrates that including such an important variable has markedly improved the model and offered strikingly different conclusions. First, I analyse the importance to include entrepot trade data and other essential macro economic variables. Then, I construct my empirical models for Hong Kong and Singapore. I apply Vector Error Correction Modelling and the Johansson Method in identifying the empirical models. In order to identify the real exchange misalignment, I filter explanatory variables and generate the potential trend data for the misalignment calculation. Furthermore, I compare the two economies in real exchange rate and analyse which regime may create a stable macro environment in terms of lower degree of REER misalignment. Rajan & Siregar (2002) find that there is noticeable REER misalignment in Hong Kong in the early years when the currency board regime was introduced. My empirical results offer some new findings that REER misalignment in Hong Kong was not that noticeable, and suggest that the currency board regime does not necessarily bring about significant REER misalignment. Adding chapter four with the previous two major chapters, I form a series
of topics on comparative studies on the currency board regime and its impacts on the Hong Kong economy, and provide valuable references to the policy maker.

I draw my overall conclusions and highlight my contributions in chapter five and also propose some interesting future research topics.
Chapter 2
Empirical models comparing the free-floating and currency board regimes in Hong Kong

2.1 Introduction

In the previous chapter, I introduced Bayoumi & Eichengreen (1994)’s paper which examines the relationship between output growth and inflation, and analysed the comparative macro performance of the pegged and float exchange rate regimes. By incorporating their empirical models within an aggregate-supply-and-demand framework, the authors inquire into the relative importance of aggregate supply and aggregate demand disturbances in periods of fixed and floating exchange rate regimes. They examine whether the impact effect of disturbances and the economy’s adjustment to them differs according to the exchange rate regime. Therefore, small SVAR models on output growth and inflation can be applied to compare different exchange rate regimes, and these models are consistent with the supply and demand framework.

In this chapter, I will conduct historical comparison between free floating and currency board periods in three ways. From 1973 - 1983, Hong Kong adopted a free-floating exchange rate regime, but since 1984 Hong Kong has been implementing a currency board regime. I run structural VAR models on the free-floating period and currency board periods. First, I compare their impulse response functions and variance decomposition of output growth and inflation. Second, I compare their sacrifice ratios, which capture the ratio of cumulative output loss to a permanent reduction in inflation. Third, I conduct some counter-factual analysis to improve our understanding of the two regimes in Hong Kong.

In order to provide a theoretical foundation for my empirical study, I examine a typical aggregate supply and demand model from Walsh (2003) for a small open economy with flexible and fixed exchange rate regimes. The theory reveals that a positive aggregate-demand shock increases prices and output in the short-run. A flexible exchange rate regime can partially offset the rise in aggregate demand by appreciation, and therefore the effect of the shock on output is smaller. A currency board regime cannot adjust its exchange rate and requires flexibility in prices and wages. My aim in this chapter is to find quantitative
Chapter 2

Evidence which is consistent with the theory and examine whether a flexible exchange rate regime can better cushion the economy after a negative external aggregate demand shock. It is outside the scope of the chapter to discuss the details of the theoretical model, since we only need to apply the conclusion of the theory. Reference of the theory can be found in Appendix A.

Research questions addressed in this chapter are:

1. Is there evidence from Hong Kong to suggest that the effect of aggregate demand shock on output is smaller under a flexible exchange rate regime than under a fixed exchange rate regime?

2. Why did Hong Kong’s recovery process from the Asian financial crisis last longer when compared with the other Asian countries that had flexible exchange rate regimes?

3. Furthermore, from the historical evidence, which regime performed better in Hong Kong in terms of macro economy stability?

4 (a). What performance would have the economy delivered during 1974 and 1983 if a currency board regime had been implemented? (b) On the contrary, how would the economy have performed during 1984-1996 if a free-floating regime had been chosen?

Methodology:

A vector autoregression (VAR) framework can be found in many recent empirical macro studies on macro economies, which aim to analyse the relationships among major macro variables such as real GDP, inflation, real interest rate, real effective exchange rate. One can use the framework to compare different exchange rate regimes, or to compare different economies and provide useful policy implications, such as Bayoumi and Eichengreen (1994). Following major literature (details in section 2.2), I examine output growth and inflation rates in my first empirical model and address the above four research questions. I will further develop the empirical models in chapters three and four. In this chapter, I first identify unrestricted VAR models on the data from both the free-floating and currency board periods. Then I apply the Banchard and Quah restrictions (neutrality of money in the long-run) as the extra restrictions to recover the structural parameters. Meanwhile, I follow Cecchetti’s model to abandon the unitary assumption in the structural residual matrix, which has been found to be inconsistent with empirical results. Unlike some literature (such as Kwan & Lui(1995)) assuming unit variance, I am supposed to indentify those variance parameters in my empirical model on the Hong Kong data and provide sound
evidence to answer my research questions. After I recover the parameters of the structural VAR models, I compute their impulse response functions, variance decompositions and sacrifice ratios. Meanwhile, I apply Runkle’s bootstrap method to calculate the 90% standard error of the impulse response function and confidence intervals for the sacrifice ratios. By comparing and analysing the above features in the SVAR models of different regimes, I will answer my first and second research questions. Moreover, I will do some counter-factual analyses based on empirical models and answer my third and fourth research questions.

2.2 Brief literature review and contribution of the chapter

Many economists have applied a vector autoregression (VAR) framework to model macroeconomies and offer useful policy references. Sims (1972, 1980) initiated the use of VAR models to estimate the impact of money on the economy. The VAR approach has been developed from bivariate (Sims 1972) to trivariate (Sims 1980) to multivariate systems. Banchard and Quah (1989) contributed to the estimation of Structural VAR models by imposing long-run theoretical restrictions, which represent the long-run neutrality of money. Summarised empirical findings of the literature can be found in Leeper, Sims and Zha (1996). Furthermore Christiano, Eichenbaum, and Evans (1999) carried out a thorough discussion of the use of VARs to estimate the impact of money. Walsh (2003) summarizes the VAR approach in his chapter on empirical evidence on money, prices and output. The author examines some detailed applications in the approach and also lists some criticisms on the approach from the literature.

One of the major virtues of the VAR model is that it only puts the lagged variables on the right-hand side, and all the left-hand side variables are supposed to be endogenous. Therefore a VAR model does not suffer from the simultaneous equations problems in which the endogenous variables are correlated with the disturbances. Since the 1980s, researchers have paid more attention to the simple, small-scale VAR models, which produce relatively satisfactory performance compared to large scale model. Moreover, VAR models have been used to study the effects of policy through impulse response functions and variance decomposition analyses.

Admittedly, using VAR model to analyse monetary policy has its limitations. One major criticism (such as Rudebusch (1998)) is about using residuals from the VAR models to represent exogenous policy shocks. How well can those residuals capture the historical policy shocks? We should look at the argument on different ways, and it depends on the
purpose of the monetary policy study. If the objective is to examine how the economy responds when a policy shock occurs, then the discrepancies among the estimated VAR residual may be of less importance. Another criticism (such as Cochrane (1998)) on VAR analysis on monetary policy study is that VAR literature fails to distinguish anticipated and unanticipated monetary policy shocks. Despite its limitations, the structural VAR approach is still one of the reliable tools in the momentary policy study so far. Therefore, I am justified to apply structural VAR models to compare the flexible and fixed exchange rate regimes in Hong Kong.

In the literature, there are two major approaches to examine economies in SVAR models.

One approach applies large SVAR models which not only contain output growth and inflation, but also include more macro variables such as money supply, interest rate, real effective exchange rate, and government spending. Literature in this approach attempts to investigate the relationship between the real effective exchange rate and other macrocosmic variables, such as Eichenbaum & Evans (1992), Clarida & Gali (1994), Rogers (1999), and Smets (1997) etc.

Eichenbaum & Evans (1992) estimate structural VAR models with five to seven endogenous variables, and show empirical evidence on the effects of monetary policy shocks on U.S exchange rates (both nominal and real). Clarida & Gali (1994) attempt to identify the source of real exchange rate fluctuations since the collapse of Bretton Woods. The authors build and estimate structural VAR models, which examine three macro variables: output growth, real exchange rate movement, and inflation. Rogers (1999) examines SVAR models which contain real government consumption growth, output growth, and first difference of real interest rate, changes in money multiplier and changes in money base. The author shows evidence to support that monetary shocks play a significant role in the movement of real effective exchange rate in the variance decomposition analysis of his SVAR models. Similar approach can be found in Smets (1997), which examines output growth, inflation, nominal interest rate and exchange rate movement in SVAR models in order to analyse the role of ECU exchange rate in three European countries.

Although many economists apply large SVAR models in studying the role of the real exchange rate on the macro economy, this approach has unavoidable limitations. These models suffer from the technical drawback of large scale SVAR, whose impulse response function and variance decomposition analyses depend heavily on the model specification:
the order of the macro variables and the increasing number of restrictions required when recovering the structural parameters. The order of the macro variables is crucial. The first variable is most important in the model, which is assumed to affect all other variables. The second variable plays a less important role in the model. While it has limited impact on the first variable, but can affect the following variables. The last variable in the model plays a ‘restricted’ role in which it is affected by all variables in the front but itself does not have significant impact on the others. Moreover, the number of restriction equations will increase dramatically when more variables are added on the structural VAR models. It is difficult to justify the restrictions and make them consistent with economic theory or actual economic condition. Therefore, large SVAR models offer limited contributions to policy analysis, given that their conclusions can be significantly different once the model specifications alter.

**Table 2-1 Number of restrictions required to recover the structural parameters from a UVAR model**

<table>
<thead>
<tr>
<th>Endogenous variables in a SVAR model</th>
<th>2 variables</th>
<th>3 variables</th>
<th>4 variables</th>
<th>5 variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of restrictions that need to be imposed</td>
<td>one</td>
<td>three</td>
<td>six</td>
<td>ten</td>
</tr>
</tbody>
</table>

Another approach adopts a more parsimony model specification, which only includes selected major variables. In most cases, only output growth and inflation are included. This approach can overcome the major drawbacks outlined above: first, it is generally agreed among economists to put output as the first variable while inflation as the second. Second, only one more extra restriction is required in order to recover the structural parameters. Most economists use the Blanchard-Quah restriction, which implies money neutrality in the long-run. Moreover, results from these models are consistent with the theoretical framework, such as aggregate supply and demand. I categorise Bayoumi & Eichengreen (1994), Cecchetti and Rich (2001) and Kwan & Lui (1996, 1999) in this approach. I will follow this approach in chapter two and three, and examine output growth and inflation across different exchange rate regimes.

Bayoumi & Eichengreen (1994) first apply the SVAR models to examine the relationship between output growth and inflation, and analyse the comparative macro performance of the pegged and float exchange rate regimes. Cecchetti & Rich (2001) estimate structural VAR models on output growth and inflation, and calculate the sacrifice ratio for the US. They computed the sacrifice ratio on three different VAR models,
beginning with Cecchetti’s (1994) two-variable system, followed by the Shapiro & Watson’s (1988) three-variable system and finally examining Gali’s (1992) four-variable system. Cecchetti’s paper shows how to decompose monetary policy into a systematic and a random component to identify changes in the stance of policy. The systematic component can be regarded as the monetary authority’s historical reaction to the economy and the random component can be interpreted as ‘monetary policy shocks’. Moreover, a policy sacrifice ratio can be estimated, which captures the cumulative output loss arising from a reduction in inflation.

Relevant studies on currency board or exchange rate regimes can be found in Schwartz (1995), Corden (2002), Hamada & Yosuke (2001) and Crosby & Otto (2003). Schwartz offers a more fundamental reflection on currency board. Corden’s paper provides a useful discussion of role played by the exchange rate regime in the 1997 Asian financial crisis. While Hamada and Yosuke point out that the currency board arrangement has been deflationary for Hong Kong, Crosby and Otto find that Hong Kong is characterised by relatively low persistence in output following an output shock. Although these studies are relevant, they have not yet addressed the research questions of this chapter.

Literature applying Structural VAR analysis to study Hong Kong’s exchange rate regimes can be found in Gerlach-Kristen (2005), Ma et al. (2007), Kwan & Lui (1996, 1999).

In Gerlach-Kristen’s empirical model (the G-K model), the author estimates a large structural VAR model which contains nine variables: output growth, CPI inflation, property price inflation, import price inflation, nominal interest rate, nominal effective exchange rate, and three major US macro variables. The authors use the empirical model to do three counterfactual simulations: First, what would the major variables look like without domestic shocks? Second, how would the model perform if a Taylor type interest rate rule was implemented? Third, what the model would be if a Singapore style interest rate rule was implemented? In the literature, large structural VAR models with more than five variables are rare. Large models have too many parameters to estimate but are subject to a limited degree of freedom in the endogenous variables. The author applies an innovative way to overcome this technical problem by estimating structural equations one by one for the six endogenous variables for Hong Kong, dropping all the insignificant variables in lag-forms, and rearranging the six structural equations plus three US structural equations into a structural VAR form. The author contributes to the literature by estimating the model and addressing the above three interesting questions. However, there are some
specification problems in the G-K model, which may significantly affect its validity. For example, with more endogenous variables in a structural model, there may be cointegration relationships among the endogenous variables, such as the cointegration among the three inflation variables, and cointegration between the Hong Kong and US interest rates. In such cases, a vector error correction (VECM) model which incorporates cointegration equations would be more appropriate. Moreover, the author puts three different inflation variables in the model and makes it difficult to interpret the results in an aggregate supply and demand framework. Furthermore, the G-K model also suffers from technical limitations of a large SVAR model: the order of the macro variables in the model plays an essential role in the analysis (impulse response function and variance decomposition) when addressing the author’s research questions. Besides these concerns, the G-K model is not a suitable model for comparing the free-floating and currency board regimes for Hong Kong, in terms of the drawbacks of large scale SVAR model mentioned above. A small structural VAR model with the advantages I have addressed above is more appropriate for my study.

In Ma et al. (2007), the authors attempt to examine the sources of macroeconomic instabilities in Hong Kong and Singapore operating under two different exchange rate regimes, by setting up large SVAR models similar to the G-K model with eight endogenous variables. However, in order to recover the structural parameter matrix, the authors have to artificially define 28 more restrictions and choose to impose zeros for all the parameters in the upper triangular of the structural parameter matrix. The authors have not yet justified these restrictions according to economic theory. Furthermore, such model specification will have the similar problem found in the G-K model, i.e., the order of the macro variables in the model play an essential role in SVAR analysis and therefore the analysis could offer limited policy implications. In this regard, small structural VAR models are more robust to carry out this empirical study.

In Kwan and Lui’s study, they used a bivariate model to capture the dynamic of output growth and inflation. They applied such a VAR model to identify the system component and random component of two different exchange rate regimes in Hong Kong: one was the floating exchange rate regime (1974 – 1983); the other was the currency board regime (1984-1997). They defined the SVAR parameters as the system components which prescribe how the economy reacts to structural shocks, and the structural residuals as the random components which could represent the shocks to the economy. They compared the two regimes by doing a hypothetical simulation, putting the random component of a currency aboard regime into a free-floating model. They attempted to find out which
regimes in Hong Kong had a better macro performance in terms of higher output growth or lower volatility in output growth and inflation.

However, Kwan and Lui’s paper makes a controversial assumption on unit variance in the residual matrix to recover their SVAR models. Such an assumption has been found to be inconsistent with the actual empirical results in Cecchetti & Rich (2001) and Green (2003). Without a unitary variance assumption, the recovered structural parameters can be significantly different to those in Kwan and Lui’s model. Therefore, it is very important to indentify a proper SVAR model for Hong Kong. Also, Kwan and Lui have not yet applied the sacrifice ratio analysis in their SVAR models comparing different exchange rate regimes in Hong Kong. The literature pays little attention to the sacrifice ratios in Hong Kong. I believe that it is essential to conduct such an analysis, when comparing the performance of different exchange regimes. I also denote the limitations of Kwan and Lui’s counter-factual analysis. They use a spectral method to deseasonalise their data before they conduct their counter-factual analysis. However, such a procedure has artificially changed the standard deviation of those endogenous variables they considered. And the estimated parameters and the residuals (shocks) from their VAR models are based on those deseasonalised data. So are their counter-factual data. It is not clear how much their ‘actual data’ and counter-factual data have been modified before the comparison. I suggest that it is more appropriate to use original data for comparison, while applying seasonal dummies as an exogenous variable in the VAR models to generate the counter-factual data. With this method both data have seasonal patterns which capture the real situation of an economy. Most important of all, I can make a fair comparison between the original data and the counter-factual data in terms of standard deviations.

Furthermore, Kwan and Lui’s paper has not focused on answering my first and second research questions. Is there evidence from Hong Kong to suggest that the effect of aggregate demand shock on output is smaller under a flexible exchange rate regime than a fixed exchange rate regime? Why did the recovery process of Hong Kong, from the Asian financial crisis, last longer when compared with the other Asian countries with a flexible exchange rate regime? According to the theory, a positive aggregate-demand shock increases prices and output. A flexible exchange rate regime can partially offset the rise in aggregate demand by appreciation, and therefore the effect of the shock on output is smaller. A currency board regime cannot adjust its exchange rate and requires domestic prices and wages to adjust with flexibility. Therefore it is necessary to find more empirical
evidence to address those questions and improve knowledge on the flexible and fixed exchange rate regimes.

2.3 The data

2.3.1 Data description and data plot

I model Hong Kong’s economy over the free floating regime from 1973 to 1983, and the currency board regime over the period 1984 to 2007, using quarterly data on constant price GDP (price level fixed at year 2005), price deflator of GDP (2005=100), and half-yearly data on population. GDP, price deflator and population data are from the Hong Kong Census and Statistics Department.

Constant price GDP data have removed the impact of inflation on output. However, population growth still has a noticeable impact on the GDP data. GDP per capita can remove such an impact. I will apply quarterly population data, which can be interpolated from the half-yearly population data.

Following Cecchetti & Rich (2001) and Kwan & Lui (1996,1999), I define quarter-to-quarter output growth as:

$$\Delta y = \log Y - \log Y(-1) \approx \frac{Y - Y(-1)}{Y(-1)}.$$

By the same token, I define quarter-to-quarter inflation as:

$$\Delta p = \log P - \log P(-1) \approx \frac{P - P(-1)}{P(-1)}.$$

I plot the data sets of log real GDP per capita, log GDP deflator and their first difference data, i.e. output growth and inflation rate for both the free-floating period and currency board period.

Data plot for the free-floating period (1974Q4-1983Q3)

Figure 2-1 Log GDP per capita and log GDP deflator

NOTE:
This figure is included on page 23 of the print copy of the thesis held in the University of Adelaide Library.
The data plot from the free-floating period exhibits normal features. Log GDP per capita and log GDP deflator both have upward trends while their first difference data, output growth and inflation rate can be regarded as stationary. Log GDP per capita does
not show a strong seasonal fluctuation in the free floating period, while it does present such a pattern in the currency board period.

The data plots from the currency board regime show a similar general pattern. However, there are also some striking differences, which may attract readers’ interest. First of all, there are two very volatile periods and slumps can be found in the log GDP per capita. One is the 1984 to 1986 period, when the Chinese and British governments began negotiations over the future handover of Hong Kong; the other is the 1997-1999 Asian financial crisis period, when there was a significant downturn in the GDP per capita. Second, the Asian financial crisis has a far more severe impact on the GDP deflator, which captures the overall price level in Hong Kong. The price level in the economy suffered from consistent deflation from 1998 until the first quarter of 2004. The plotting of quarter-to-quarter change in inflation rate also exhibits a noticeably below average pattern during that crisis period.

2.3.2 Unit root test

I report the unit root test results in Table 2-2, where GY01 and PAI01 represent the data series of output growth rate and inflation rate respectively. I apply both the Augmented Dickey-Fuller (ADF) test and Phillips-Peron (PP test). For the data from the free-floating period, one can arbitrarily accept that both output growth and inflation rate are stationary. The p-value of the inflation data is slightly over 5% in the Augmented Dickey-Fuller test, but the p-value in the Phillips-Peron is 0.3%. Therefore I will retain the null hypothesis that the inflation data is stationary at a significance level higher than 5%. For the data from the currency board period, the output growth is consistently identified as stationary by the two tests, however, there are mixed results for the inflation data. In the ADF test the p-value of inflation is 8.93%, which is far bigger than 5%. I will reject the null hypothesis and conclude that there is evidence that the inflation data has a unit root. This result is consistent with my data plot and I had pointed out that the Asian financial crisis had depressed the price level in Hong Kong significantly and consistently for almost six years since 1998. Therefore, there is a noticeable structural change in my data during the currency board period. I need to address this issue before I carry out further empirical modelling.
Table 2-2 Unit root test 1 (Lag Length: 2)

<table>
<thead>
<tr>
<th></th>
<th>Free floating period (1974-1983)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Null hypothesis</td>
<td>Augmented Dickey-Fuller</td>
<td>Phillips-Peron</td>
</tr>
<tr>
<td>GY01 has a unit root</td>
<td>P-value=0.0000</td>
<td>P-value=0.0000</td>
<td></td>
</tr>
<tr>
<td>PAI01 has a unit root</td>
<td>P-value=0.0507</td>
<td>P-value=0.0003</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Currency board period (1984-2007)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Null hypothesis</td>
<td>Augmented Dickey-Fuller</td>
<td>Phillips-Peron</td>
</tr>
<tr>
<td>GY01 has a unit root</td>
<td>P-value=0.0001</td>
<td>P-value=0.0000</td>
<td></td>
</tr>
<tr>
<td>PAI01 has a unit root</td>
<td>P-value=0.0893</td>
<td>P-value=0.0000</td>
<td></td>
</tr>
</tbody>
</table>

2.3.3 Two models for the currency board period

There are two options to address the issue of structural change in the data of the currency board period. One is to use the pre-crisis data to model Hong Kong’s economy; the other is to apply a dummy variable regression to eliminate the impact of the Asian financial crisis effect from the full currency board period data. I have decided to adopt both methods and compare their results. There are a few advantages for modelling both. First, the pre-crisis data can give us a baseline view of the economy which had not been affected by the Asian financial crisis. Second, the full currency board period model can be regarded as an alternative model in which the impact of the crisis has been artificially eliminated. Third, I can compare the free floating model with the pre-crisis currency board model more convincingly in the latter part of this chapter, because these two models cover similar length of quarters. Fourth, it is also easier to compare the empirical models with Kwan & Lui’s (1995, 1999) models within the similar time span.

- A pre-crisis model (a baseline model)

I take a sub-sample data from the currency board period, 1984Q1 to 1996Q4. I plot the data and conduct Augmented Dickey-Fuller and Phillips-Peron unit root tests again. Unlike Figure 2-4, Figure 2-6 on output growth and inflation both exhibit stationary features across the time period I consider. Furthermore, both unit root tests have rejected the null hypothesis that output growth and inflation data have a unit root.
Chapter 2

Data plot for the pre-crisis model (1984Q1-1996Q4)

Figure 2-5 Log GDP per capita and log GDP deflator

<table>
<thead>
<tr>
<th>Null hypothesis</th>
<th>Augmented Dickey-Fuller</th>
<th>Phillips-Peron</th>
</tr>
</thead>
<tbody>
<tr>
<td>GY01 has a unit root</td>
<td>P-value=0.0001</td>
<td>P-value=0.0000</td>
</tr>
<tr>
<td>PAI01 has a unit root</td>
<td>P-value= 0.0003</td>
<td>P-value=0.0000</td>
</tr>
</tbody>
</table>

A crisis-adjusted model (a reference model)

I take a full sample data from the currency board period, 1984Q1 to 2007Q4. I use a dummy regression to eliminate the crisis effect, which has depressed inflation significantly from 1998 until the first quarter of 2004. From the above unit root test, I am aware that the crisis impact on output growth is minor, because the series are stationary. Even if I impose a crisis dummy variable regression on output growth data, the adjustment will not be significant. Therefore, I will use a crisis dummy variable to adjust the crisis effect for inflation. I originally defined my crisis dummy variable dl=1 from 1998Q1 to 2003Q4, and dl=0 otherwise, according to the timing period of the Asian financial crises. Given that

Source of data: Hong Kong C&S Department.

Table 2-3 Unit root test 2 (Lag Length: 2)
it took around three years for Hong Kong to gradually recover from the crises since 2004Q1, a three-year transition period has been selected for the crisis effect to phase out smoothly in the dummy variable regression.

I may need to address the seasonal fluctuation issue here, or later in the following VAR model. I decide that here I will simultaneously use a seasonal dummy to eliminate the seasonal effects, since I am using a dummy variable regression to eliminate the impact of the crises on inflation. For the free-floating model and the pre-crisis currency board model, I will address the seasonal fluctuation later in the VAR model by putting the seasonal dummies directly into the exogenous variable section.

I put my dummy variable regression details in the Appendix B.1. I generate two residual series from those dummy variable regressions and construct the adjusted data by adding the intercepts. I plot the adjusted data and tablet their unit root test results as follows:

**Figure 2-7 Data plot for the crisis-adjusted model (1984Q1-2007Q4)**

![Data plot for the crisis-adjusted model (1984Q1-2007Q4)](image)

**Note:**
This figure is included on page 28 of the print copy of the thesis held in the University of Adelaide Library.

*Source of data: Hong Kong C&S Department.*

**Table 2-4 Unit root test 3 (Lag Length: 2)**

<table>
<thead>
<tr>
<th>Currency board period (1984Q1-2007Q4)</th>
<th>Augmented Dickey-Fuller</th>
<th>Phillips-Peron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null hypothesis</td>
<td>P-value=0.0001</td>
<td>P-value=0.0000</td>
</tr>
<tr>
<td>GY02 has a unit root</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAI02 has a unit root</td>
<td>P-value=0.0000</td>
<td>P-value=0.0000</td>
</tr>
</tbody>
</table>

The adjusted inflation data plot shows a satisfactory pattern of stationary in which the Asian financial crisis impact has been deliberately removed. Both Augmented Dickey-Fuller and Phillips-Peron tests indicate that one can reject the null hypothesis of the existence of a unit root and concludes that the inflation data is stationary. Moreover, the seasonal pattern has been successfully removed.
2.4 A structural VAR model

Following Cecchetti (2001), I consider the following two-variable structural VAR model.

I use $\Delta y_t, \Delta p_t$ to represent output growth and inflation.

$$
\Delta y_t = c_1 + \sum_{i=1}^{n} b_{1i} \Delta y_{t-i} + b_{12} \Delta p_t + \sum_{i=1}^{n} b_{i1} \Delta p_{t-i} + \epsilon_t^y
$$

$$
\Delta p_t = c_2 + b_{21} \Delta y_t + \sum_{i=1}^{n} b_{i1} \Delta y_{t-i} + \sum_{i=1}^{n} b_{i2} \Delta p_{t-i} + \epsilon_t^\pi.
$$

(2.4.1)

The superscript refers to the index of the sequence of coefficient.

Moving all the $\Delta y_t$ and $\Delta p_t$ to the left hand side of the equations in 2.4.1, I can write the model into a structural form:

$$
B_0 X_t = C + B_1 X_{t-1} + B_2 X_{t-2} + \cdots + B_n X_{t-n} + E_t,
$$

(2.4.2)

$$
B_0 = \begin{bmatrix} b_{11}^0 & b_{12}^0 \\ b_{21}^0 & 1 \end{bmatrix}, \quad X_t = \begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix}, \quad C = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}, \quad B_n = \begin{bmatrix} b_{11}^n & b_{12}^n \\ b_{21}^n & b_{22}^n \end{bmatrix}, \quad E_t = \begin{bmatrix} \epsilon_t^y \\ \epsilon_t^\pi \end{bmatrix}.
$$

Here $E_t = [\epsilon_t^y, \epsilon_t^\pi]'$ is a vector innovation process that contains shocks to aggregate supply ($\epsilon_t^y$) and aggregate demand ($\epsilon_t^\pi$).

Note: all the superscripts in every entry of $B_n$ represent the number sequence of the parameters, not the power of the entry.

As I mentioned in literature review, I am not supposed to impose unit variance in the error term in the structural VAR model, and I will identify those variances later. Instead of assuming $\text{Var}(E_t)$ is an identity matrix, I have the variance matrix of the error term as follows:

$$
\text{var}(E_t) = \begin{bmatrix} v_1 & 0 \\ 0 & v_2 \end{bmatrix}.
$$

As commonly assumed in the literature (such as Cecchetti & Rich (2001) and Green (2003)), I assume that there are uncorrelated relationships between aggregate supply ($\epsilon_t^y$) and aggregate demand ($\epsilon_t^\pi$) throughout chapter two and three.

The structural VAR cannot be directly estimated, given that the error terms correlate of the contemporary explanatory variables. However, one can recover the structural VAR from the unrestricted VAR system, which has the following form:

$$
X_t = CC + D_1 X_{t-1} + D_2 X_{t-2} + \cdots + D_n X_{t-n} + U_t,
$$

or in detailed form:
\[ \Delta y_t = cc_1 + \sum_{i=1}^{n} d_{1i} \Delta y_{t-i} + \sum_{i=1}^{n} d_{12i} \Delta p_{t-i} + u_t \]  \hspace{2cm} (2.4.3)

\[ \Delta p_t = cc_2 + \sum_{i=1}^{n} d_{2i} \Delta y_{t-i} + \sum_{i=1}^{n} d_{22i} \Delta p_{t-i} + u_t \]

\[ CC = \begin{bmatrix} cc_1 \\ cc_2 \end{bmatrix}, \quad D_n = \begin{bmatrix} d_{11}^n \\ d_{12}^n \\ d_{21}^n \\ d_{22}^n \end{bmatrix}, \quad U_t = \begin{bmatrix} u_t^x \\ u_t^y \end{bmatrix}, \quad \text{var}(U_t) = \Omega = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{21} & \sigma_2^2 \end{bmatrix}. \]

**Note:** all the superscripts in every entry of \( D_n \) represent the number sequence of the parameters, not the power of the entry.

I have the following relations among the covariance entries: \( \sigma_{12} = \sigma_{21} \).

- From an unrestricted VAR to a structural VAR

When I compare unrestricted VAR equation (2.4.3) with structural VAR equation (2.4.2), I note that if I invert the coefficient matrix \( B_0 \) to the right hand side, structural VAR (2.2.2) has the same form as unrestricted VAR, equation (2.4.3):

\[ X_t = B_0^{-1} C + B_0^{-1} B_1 X_{t-1} + B_0^{-1} B_2 X_{t-2} + \cdots + B_0^{-1} B_n X_{t-n} + B_0^{-1} E_t, \]

where \( B_0^{-1} C = CC, B_0^{-1} B_1 = D_n, B_0^{-1} E_t = U_t \). If I can recover the matrix \( B_0 \), I can recover the whole structural VAR from the unrestricted VAR system. For the convenience of notation, I have \( A_0 = B_0^{-1} \), which is defined as a 3 by 3 matrix in this chapter.

\[ X_t = A_0 C + A_0 B_1 X_{t-1} + A_0 B_2 X_{t-2} + \cdots + A_0 B_n X_{t-n} + A_0 E_t. \]

After I estimate the unrestricted VAR equation (2.4.3) model, I can recover my structural VAR equation (2.4.2) model as follows:

I know \( B_0^{-1} E_t = U_t \), therefore I have

\[ \text{var}(U_t) = \Omega = \text{var}(B_0^{-1} E_t) = B_0^{-1} \text{var}(E_t)(B_0^{-1})'. \]  \hspace{2cm} (2.4.4)

That is, \( \Omega = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{21} & \sigma_2^2 \end{bmatrix} = \begin{bmatrix} 1 & b_{12}^0 \\ b_{21}^0 & 1 \end{bmatrix}^{-1} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} \begin{bmatrix} 1 & b_{12}^0 \\ b_{21}^0 & 1 \end{bmatrix}. \)  \hspace{2cm} (2.4.5)

From equation (2.4.5), I have four different entries in the \( \text{var}(U_t) \): \( \sigma_1^2, \sigma_{12}, \sigma_{21}, \sigma_2^2 \), but I can only write three equations given that \( \sigma_{12} = \sigma_{21} \). However, I have 4 unknowns that need to be identified: \( b_{12}^0, b_{21}^0, v_1, v_2 \). I am required to impose one more restriction equation to just identify the coefficients.
I follow Cecchetti & Rich (2001) and Green (2003) to impose the Blanchard-Quah long-run restriction that monetary impacts on output in the long-run are zero, i.e. aggregate demand has no permanent effect on output growth.

First, I need to rewrite the unrestricted VAR into a Vector Moving Average (VMA) representation:

\[
[I - D_1 L - D_2 L^2 - \cdots - D_n L^n]X_t = CC + U_t;
\]

I defined \(F = [I - D_1 L - D_2 L^2 - \cdots - D_n L^n]^{-1}\),

\[X_t = F.CC + F.U_t,\]

\[
\bar{X} = E(X_t) = F.CC, \quad \text{and} \quad \bar{X} = \begin{bmatrix} \bar{\Delta y} \\ \bar{\Delta p} \end{bmatrix}.
\]

\[X_t - \bar{X} = F.U_t = F.B_0^{-1}.E_t = F.A_{0}.E_t. \quad (2.4.6)\]

Second, I impose the Blanchard-Quah restriction, i.e. \(A_{12}(L) = 0\). This restriction is also called long-run neutrality of money on output growth.

\[F.A_0 = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix}.\]

We write equation (2.4.6) in detailed form:

\[
\begin{bmatrix} \Delta y_t - \bar{\Delta y} \\ \Delta p_t - \bar{\Delta p} \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^\pi \end{bmatrix}. \quad (2.4.7)
\]

Details on structural shocks:

Following literature such as Bayoumi & Eichengreen (1994), Cecchetti & Rich (2001), I regard structural shocks (\(\varepsilon_t^y\) and \(\varepsilon_t^\pi\)) as aggregate supply and demand shocks (\(\varepsilon^{AS}\) and \(\varepsilon^{AD}\) respectively).

If we define \(\Delta y_t = gy_t\) and \(\Delta p_t = pai_t\), Equation (2.4.7) becomes

\[
\begin{bmatrix} gy_t - \bar{gy} \\ pai_t - \bar{pai} \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_t^{AS} \\ \varepsilon_t^{AD} \end{bmatrix}. \quad (2.4.8)
\]

From \(B_0^{-1}E_t = U_t\), I can write

\[
E_t = B_0.U_t, \quad \text{i.e.} \quad \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^\pi \end{bmatrix} = \begin{bmatrix} 1 & b_{12}^{0} \\ b_{21}^{0} & 1 \end{bmatrix} \begin{bmatrix} u_t^y \\ u_t^\pi \end{bmatrix}. \quad (2.4.9)
\]
Therefore, the aggregate supply and aggregate demand shocks are actually the combinations of unrestricted output and inflation shocks ($u_t^y$ and $u_t^\pi$ respectively). The weights of the combinations are decided by the structural parameters in the matrix $B_0$.

From equation (2.4.9), I can make the structural shocks as clear as follows:

$$\varepsilon_t^{AS} \equiv \varepsilon_t^y = u_t^y + b_{12}^0 u_t^\pi$$
$$\varepsilon_t^{AD} \equiv \varepsilon_t^\pi = b_{21}^0 u_t^y + u_t^\pi.$$  \hspace{1cm} (2.4.10)

### 2.5 Empirical results and analysis for questions one and two

In this section, I recover the structural VAR parameters for the empirical models and conduct some SVAR analyses, such as the Impulse Response Functions (IRFs), variance decomposition and sacrifice ratios Analysis. My aim in this section is to find some empirical evidence to answer the following two questions:

- *Is there evidence from Hong Kong to suggest that the effect of aggregate demand shock on output is smaller under a flexible exchange rate regime than under a fixed exchange rate regime?*
- *Why did Hong Kong’s recovery process from the Asian financial crisis last longer when compared with the other Asian countries which had flexible exchange rate regimes?*

#### 2.5.1 Identifying structural parameters from those of a unrestricted VAR (UVAR) model

First, I use Eviews software to examine the lag order selection criteria for the Currency Board and the pre-crisis models, which helps to identify the proper number of lags in the model specifications. The selection criteria contain five tests, including sequential modified LR test statistic (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SIC) & Hannan-Quinn information criterion (HQ). According to the test results, lags from 1-3 are preferable for the two empirical models. Considering the usage of quarter-to-quarter change data and limited degree of freedom in these models, I choose two lags as a proper model specification. Moreover, the lag structure selection across models is required to be consistent (two lags for all models), since I am supposed to conduct some counter-factual analysis in section 2.6. Details of the lag selection criteria tests are enclosed in Appendix B.2.
Second, I estimate the parameters of unrestricted VAR models and check the model adequacy. The UVAR models are specified on output growth and inflation, with two lags structure and seasonal dummies on the exogenous section. The model adequacy check includes: VAR Residual Portmanteau Tests for Autocorrelations, VAR Residual Serial Correlation LM Tests & VAR Residual Normality Tests. The test results fairly indicated that the empirical models do not suffer from serious autocorrelations in the residuals and the residuals exhibit normality. Therefore, the robustness of the UVAR models is assured. Details of the model adequacy test are enclosed in Appendix B.3.

Third, I recover structural parameters from those of an unrestricted VAR model as follows.

I estimate the parameters of an Unrestricted VAR:
\[
X_t = CC + D_1X_{t-1} + D_2X_{t-2} + U_t.
\]

I get a constant vector \(CC\), parameter matrix \(D_1, D_2\) and variance-covariance matrix \(\text{var}(U_t)\). From \(\text{var}(U_t)\) I can generate three equations. Moreover, in order to just-identify the structural model, I am required to provide one more equation by imposing the Blanchard and Quah long-run restrictions. I identify the structural parameters in \(B_0\) and \(\text{Var}(E_t)\) in the Mathematica program for all the three empirical models. Reference of the methodology from Hamilton (1995) is listed in Appendix C.

Let me use the free-floating model as an example. From the equations, I recover the structural VAR model parameters as follow:
\[
B_0 = \begin{bmatrix} 1 & 0.712861 \\ -0.0215097 & 1 \end{bmatrix},
\]
\[
A_0 = B_0^{-1} = \begin{bmatrix} 0.984898 & -0.702095 \\ 0.0211849 & 0.984898 \end{bmatrix},
\]
\[
\text{Var}(E_t) = \begin{bmatrix} 14.3104 & 0 \\ 0 & 2.21574 \end{bmatrix}.
\]

From these results, I illustrate the importance of the methodology I applied in indentifying my structural VAR model. While the Kwan & Lui (1996,1999) models assume unitary variance in the error term \(\text{var}(E_t) = \begin{bmatrix} v_1 & 0 \\ 0 & v_2 \end{bmatrix}\), where \(v_1 = 1, v_2 = 1\); my empirical results suggest that the variance of error term is not necessarily unitary, instead, \(v_1\) and \(v_2\) are actually significantly different from one. The same findings are also reported in Cecchetti & Rich (2001) and Green (2003).
After the structural VAR model is identified, I convert it into a Vector Moving Average form (VMA). Then I can conduct impulse response function analysis and variance decomposition analysis, which together are also called innovation accounting analysis. They are useful tools to examine the relationships of the explanatory variables. Moreover, I can estimate the sacrifice ratio between output and inflation from VMA. Before I go to the IRFs and variance decomposition analysis section, it is necessary to examine the characteristics of the structural shocks across the different exchange rate regimes.

After I recovered the structural parameters for three empirical models, I can use each indentified $B_i$ to compute the aggregate supply and aggregate demand shocks, following equation (2.4.10). Descriptive statistics in Table 2-5 reveal that aggregate supply shocks are more volatile than the aggregate demand shocks across different exchange rate regimes. Moreover, evidence illustrates that both aggregate demand and supply shocks are more volatile during the free-floating period. Furthermore, the structural shocks statistics are consistent for the two models for the currency board period.

Can these statistics answer my first two research questions? The answer is not yet, because the statistics just indicate the magnitude and volatility of the historical shocks, but they fail to show how the economy responds to the shocks. Therefore, further analysis is necessary to address those questions.

**Table 2-5 Descriptive statistics for aggregated supply and demand shocks across different exchange rate regimes**

<table>
<thead>
<tr>
<th></th>
<th>Free-floating period</th>
<th>Currency board period (the pre-crisis model)</th>
<th>Currency board period (the crisis-adjusted model)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AS shocks</td>
<td>AD shocks</td>
<td>AS shocks</td>
</tr>
<tr>
<td>Mean</td>
<td>2.94118E-06</td>
<td>-3.26536E-17</td>
<td>8E-06</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.357796454</td>
<td>1.32170079</td>
<td>1.933030585</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.258076937</td>
<td>-0.317188527</td>
<td>-0.703757306</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>0.823639675</td>
<td>0.824978756</td>
<td>2.92500739</td>
</tr>
<tr>
<td>Minimum (%)</td>
<td>-6.2747</td>
<td>-3.6205</td>
<td>-7.2947</td>
</tr>
<tr>
<td>Maximum (%)</td>
<td>9.7483</td>
<td>2.9892</td>
<td>3.851</td>
</tr>
<tr>
<td>Count</td>
<td>34</td>
<td>34</td>
<td>50</td>
</tr>
</tbody>
</table>

Data.
2.5.2 Impulse response function (IRF) and variance decomposition

First, I use Matlab to draw the impulse response function of structural VAR models by applying the algorithm from Hamilton (1995). Moreover, I will follow Runkle (1987) in...
applying a bootstrap method to calculate the 90% standard error of the impulse response
function, given that it is not certain whether the distribution of the error term is Gaussian. The computed impulse response function and its standard error series are stored for calculating the sacrifice ratio and its confidence intervals. Following Cecchetti and Rich (2001), I regard output growth shocks as aggregate supply shocks in a two-variable SVAR, and I use inflation shocks to represent aggregate demand shocks. Components of those structural shocks have been shown in equations (2.4.8-2.4.10).

Second, I use Mathematica to compute the variance decomposition table of my structural VAR model by applying the algorithm from Hamilton (1995). The variance decompositions for output growth and inflation have been examined for up to 20 quarters. Hence, I can identify the relatively importance of each shock on the variances of output growth and inflation in a quantitative way. These variances are also named forecast errors. In general, the variance decompositions for each variable remain relatively stable across time after 3 quarters and especially, those over 10 quarters or longer.

Notes of the algorithm from Hamilton (1995) are enclosed in the Appendix C.

Before I proceed to compare the free-floating and currency board regimes in 2.5.2.4, I first carry out three relevant discussions in the following subsections.

2.5.2.1 Comparing SVAR and UVAR models for the free-floating period

The aim of this section is to address the question on why a SVAR model is more appropriate to capture the economy. Equation (2.4.10) already shows that the aggregate supply and demand shocks are actually the combinations of unrestricted output and inflation shocks ($u^*_t$ and $u^r_t$ respectively). The weights of the combinations are decided by the structural parameters in the matrix $B_o$. Therefore it is necessary to recover the structural parameters.

Furthermore, I use the free-floating model as an example to illustrate the difference in the Impulse Response Functions (IRFs) between the unrestricted VAR (UVAR) model and the structural VAR (SVAR) model. In both models, the IRFs of output growth to an output shock are nearly identical. However, the rest of the three IRFs have changed either significantly or slightly. The most significant changes are found in the IRF of output growth to inflation shock (demand shock), the upper-right plots. In the UVAR model in Figure 2-11, output growth has only a tiny positive response. On the contrary, the response of output growth is much more sensitive in the SVAR model. It illustrates that output...
growth first drops approximately 1% in the first quarter, then immediately moves to positive growth of approximately 0.8% in the second quarter. Such a difference will have strong implications in the sacrifice ratio analysis in the latter part of this chapter. Furthermore, it reveals the importance of my structural VAR models. For the above reasons, one can see that unrestricted VAR models fail to capture the real situation of the economy and would are incompetent to provide reliable policy implications. Equation (2.4.1) also denotes the necessity to identify parameters $b_{12}^0$ and $b_{21}^0$, because output and inflation may deliver contemporary impacts on each other within a quarter.

In the IRFs for the free-floating period, output growth is substantially affected by output (supply) shock. Figure 2-12 shows that one standard deviation positive output shock can stimulate output growth by 4 percentage points in the first quarter. After the ‘overshooting’, the output growth adjusts itself by reducing 2 percentage points in the second quarter and phases out most of the shock effect in the fourth quarter. Meanwhile, the impact of inflation (demand) shock on output growth rate is noticeably smaller on both SVAR and UVAR. After imposing the Blanchard-Quah restriction, which represents the long-run neutrality of inflation (demand) shocks on output, the response of output growth to inflation shocks has changed significantly. Output growth first turns negative in the first quarter, then immediately moves to positive growth in the second quarter. Therefore the overall effect of the inflation (demand) shock has limited impact on output growth in the long run. Moreover, inflation (demand) shock is the major source of fluctuations for inflation. One standard deviation inflation (demand) shock can induce inflation by 1.5 percentage point in the first quarter, while output (supply) shock accounts for moderate impact on inflation in maximum of 0.5 percentage point in the third quarter.
Evidence in the variance decomposition also denotes the importance of identifying structural parameters. Evidence suggests that the variance decomposition results of the two models are noticeably different from each other. For example, in quarter 20 output shock (aggregate supply shock) accounts for about 99% of the output variance in the UVAR model, while it can explain about 93% of the output variance in the SVAR model.
Therefore it is necessary to identify parameters $b_{12}^0$ and $b_{21}^0$ as output and inflation may have contemporary impact on each other, within a quarter.

Moreover, evidence reveals that each variance-decomposition table is consistent with the impulse response analysis in both UVAR and SVAR. The difference between the two variance decomposition tables also exemplifies the importance of recovering the parameters of a structural VAR model from an unrestricted VAR.

**Table 2-6 Variance decomposition for a UVAR: the free-floating period (1974-1983)**

<table>
<thead>
<tr>
<th>Period</th>
<th>Output Shocks ($u_t^y$)</th>
<th>Inflation Shocks ($u_t^p$)</th>
<th>Period</th>
<th>Output Shocks ($u_t^y$)</th>
<th>Inflation Shocks ($u_t^p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>0</td>
<td>1</td>
<td>4.71605</td>
<td>95.2839</td>
</tr>
<tr>
<td>2</td>
<td>99.8751</td>
<td>0.124948</td>
<td>2</td>
<td>5.12731</td>
<td>94.8727</td>
</tr>
<tr>
<td>3</td>
<td>99.2353</td>
<td>0.764709</td>
<td>3</td>
<td>12.1591</td>
<td>87.8409</td>
</tr>
<tr>
<td>4</td>
<td>99.2349</td>
<td>0.765102</td>
<td>4</td>
<td>12.0831</td>
<td>87.9169</td>
</tr>
<tr>
<td>5</td>
<td>99.2259</td>
<td>0.774114</td>
<td>5</td>
<td>12.0226</td>
<td>87.9774</td>
</tr>
<tr>
<td>8</td>
<td>99.2187</td>
<td>0.781251</td>
<td>8</td>
<td>12.0274</td>
<td>87.9726</td>
</tr>
<tr>
<td>12</td>
<td>99.2186</td>
<td>0.781441</td>
<td>12</td>
<td>12.0272</td>
<td>87.9728</td>
</tr>
<tr>
<td>16</td>
<td>99.2186</td>
<td>0.781443</td>
<td>16</td>
<td>12.0272</td>
<td>87.9728</td>
</tr>
<tr>
<td>20</td>
<td>99.2186</td>
<td>0.781443</td>
<td>20</td>
<td>12.0272</td>
<td>87.9728</td>
</tr>
</tbody>
</table>

**Table 2-7 Variance decomposition for a SVAR: the free-floating period (1974-1983)**

<table>
<thead>
<tr>
<th>Period</th>
<th>Aggregate Supply Shocks ($\varepsilon_t^y$)</th>
<th>Aggregate Demand Shocks ($\varepsilon_t^p$)</th>
<th>Period</th>
<th>Aggregate Supply Shocks ($\varepsilon_t^y$)</th>
<th>Aggregate Demand Shocks ($\varepsilon_t^p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>94.145</td>
<td>5.85496</td>
<td>1</td>
<td>2.63159</td>
<td>97.3684</td>
</tr>
<tr>
<td>2</td>
<td>93.3802</td>
<td>6.61985</td>
<td>2</td>
<td>2.96583</td>
<td>97.0342</td>
</tr>
<tr>
<td>3</td>
<td>93.2381</td>
<td>6.76193</td>
<td>3</td>
<td>12.2819</td>
<td>87.7181</td>
</tr>
<tr>
<td>4</td>
<td>93.2417</td>
<td>6.75832</td>
<td>4</td>
<td>12.1814</td>
<td>87.8186</td>
</tr>
<tr>
<td>5</td>
<td>93.2339</td>
<td>6.76615</td>
<td>5</td>
<td>12.1432</td>
<td>87.8568</td>
</tr>
<tr>
<td>8</td>
<td>93.2282</td>
<td>6.77179</td>
<td>8</td>
<td>12.1697</td>
<td>87.8303</td>
</tr>
<tr>
<td>12</td>
<td>93.2281</td>
<td>6.77192</td>
<td>12</td>
<td>12.17</td>
<td>87.83</td>
</tr>
<tr>
<td>16</td>
<td>93.2281</td>
<td>6.77192</td>
<td>16</td>
<td>12.17</td>
<td>87.83</td>
</tr>
<tr>
<td>20</td>
<td>93.2281</td>
<td>6.77192</td>
<td>20</td>
<td>12.17</td>
<td>87.83</td>
</tr>
</tbody>
</table>
2.5.2.2 The selection between the pre-crisis model and the crisis-adjusted model

The impulse response functions of the two currency board models share common patterns, and the pre-crisis model is actually a sub-sample model. If there were no fundamental changes in the economy, the parameters of the two SVAR models should be consistent with each other.

On one hand, there were two very similar subplots such as the response of output growth to output (supply) shocks and the response of inflation to inflation (demand) shocks. On the other hand, the other two subplots look more sensitive to their counter-part shocks in the pre-crisis model. For instance, figure 2-13 shows that the output is more sensitive to inflation (demand) shocks, compared to figure 2-14. Furthermore, Figure 2-13 also shows that inflation is more sensitive to output (supply) shock in the pre-crisis model. Given that the Asian financial crisis hit the economy in the full-sample model, I use crisis dummy variable regression to eliminate the crises effect from the inflation data. Both these two factors may have a crucial impact on IRFs of the full-sample model (Figure 2-14) and make the IRFs to the counterpart shocks less sensitive. Based on these two reasons, it is reasonable to believe that the pre-crisis model is a favorite model for the currency board period.

*Figure 2-13 Impulse response function for a SVAR: the currency-board period (pre-crisis, 1984-1996)*
Evidence suggests the similar patterns for in the variance decomposition analyses. In the pre-crisis model, aggregate demand shock explains approximately 11% of the output growth variance in quarter 20, while in the crisis-adjusted model, inflation shock can only account for approximately 3.6% of the output growth variance. Furthermore, the aggregate supply shocks account for approximately 36% of the inflation variance in the pre-crisis model in quarter 20, while aggregate supply shocks can only explain approximately 7.8% of the inflation variance in the crisis-adjusted model. In the crisis-adjusted model, the Asian financial crisis and the crisis dummy variable regression both deliver significant impacts on the inflation data. Therefore, it is more reliable to use the pre-crisis model as the preferable example when comparing a currency board regime with a free-floating regime.
Table 2-8 Variance decomposition for a SVAR: the currency-board period (pre-crisis 1984-1996)

<table>
<thead>
<tr>
<th>Period</th>
<th>Aggregate Supply Shocks ($\varepsilon_i^y$)</th>
<th>Aggregate Demand Shocks ($\varepsilon_i^p$)</th>
<th>Variance decomposition of inflation ($\Delta p_i$) in percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>94.9349</td>
<td>5.0651</td>
<td>12.1131</td>
</tr>
<tr>
<td>2</td>
<td>94.5213</td>
<td>5.47867</td>
<td>14.4003</td>
</tr>
<tr>
<td>3</td>
<td>88.8875</td>
<td>11.1125</td>
<td>36.1135</td>
</tr>
<tr>
<td>4</td>
<td>88.8873</td>
<td>11.1127</td>
<td>36.1496</td>
</tr>
<tr>
<td>5</td>
<td>89.1832</td>
<td>10.8168</td>
<td>35.07</td>
</tr>
<tr>
<td>8</td>
<td>88.8928</td>
<td>11.1072</td>
<td>35.9248</td>
</tr>
<tr>
<td>12</td>
<td>88.8921</td>
<td>11.1079</td>
<td>35.9008</td>
</tr>
<tr>
<td>16</td>
<td>88.8919</td>
<td>11.1081</td>
<td>35.8988</td>
</tr>
<tr>
<td>20</td>
<td>88.8919</td>
<td>11.1081</td>
<td>35.8987</td>
</tr>
</tbody>
</table>

Table 2-9 Variance decomposition for a SVAR: the currency-board period (crisis adjusted 1984-2007)

<table>
<thead>
<tr>
<th>Period</th>
<th>Aggregate Supply Shocks ($\varepsilon_i^y$)</th>
<th>Aggregate Demand Shocks ($\varepsilon_i^p$)</th>
<th>Variance decomposition of inflation ($\Delta p_i$) in percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99.703</td>
<td>0.296979</td>
<td>3.50606</td>
</tr>
<tr>
<td>2</td>
<td>98.5393</td>
<td>1.46072</td>
<td>3.78574</td>
</tr>
<tr>
<td>3</td>
<td>96.4826</td>
<td>3.51744</td>
<td>7.62026</td>
</tr>
<tr>
<td>4</td>
<td>96.4647</td>
<td>3.53526</td>
<td>7.64336</td>
</tr>
<tr>
<td>5</td>
<td>96.4855</td>
<td>3.51466</td>
<td>7.71581</td>
</tr>
<tr>
<td>8</td>
<td>96.4404</td>
<td>3.55963</td>
<td>7.76236</td>
</tr>
<tr>
<td>12</td>
<td>96.4398</td>
<td>3.56018</td>
<td>7.76433</td>
</tr>
<tr>
<td>16</td>
<td>96.4398</td>
<td>3.5602</td>
<td>7.76435</td>
</tr>
<tr>
<td>20</td>
<td>96.4398</td>
<td>3.5602</td>
<td>7.76435</td>
</tr>
</tbody>
</table>
2.5.2.3 Are the IRFs analyses consistent with the aggregate supply and demand framework?

According to the theoretical framework, the aggregate supply curve is vertical in the long-run, which means output is decided by the supply side factors (such as labor supply, capital and technological progress), not the demand side factors. Moreover, the aggregate demand curve is downward sloping according to the IS-LM model. Figure 2-15 illustrates the shapes of aggregate supply and demand curves, which set the original output and price level at $y_0$ and $p_0$.

![Aggregate supply and demand curves in the long-run](image)

First, I examine a positive output (aggregate supply) shock. The left-hand-side subplots in Figures 2-12 and 2-13 illustrate that one positive supply shock both increases output and inflation. However, the theoretical framework suggests that supply shocks only increase output level, but decrease price level, assuming no change in the aggregate demand curve. In order to address this discrepancy, one may attempt to find the explanation in an aggregate demand curve. It can be the case that aggregate supply shocks do bring some proportion (not necessarily 100%) increase in aggregate demand, i.e. the aggregate demand curve also moves to the right. Figure 2-16 shows that a positive aggregate demand shocks shifts AS curve to the right and increases the output level. Without the shift of the aggregate demand curve from $AD_0$ to $AD_1$, price level is supposed to be lower. Here I do not intend to make a controversial statement in showing evidence to support the Say’s law that supply creates demand. I just point out a possible circumstance which is consistent with the empirical models for Hong Kong.
Second, a positive inflation (aggregate demand) shock only increases the price level, but cannot increase the output in the long-run, given a vertical aggregate supply curve. This pattern can be found on the right-hand-side subplots in Figures 2-12 and 2-13 in my IRFs. Therefore, my IRFs analyses on the aggregate demand shocks are consistent with the theoretical framework. Admittedly, I apply the Blanchard-Quah restriction which defines money neutrality in the long-run in my SVAR models.

2.5.2.4 Comparing SVAR models for the free-floating and currency board periods
In this section I commence to compare the two exchange rate regimes, after clarifying three relevant issues from 2.5.2.1 to 2.5.2.3 and selecting the appropriate models. I am going to compare Figures 2-12 and 2-13 in the IRFs plots, and compare Tables 2-7 and 2-8 in the variance decomposition analyses.

When I compare the two IRFs plots, I attempt to find some evidence which can answer my research questions. As I mentioned as the beginning of this chapter, according
to the theory, a positive aggregate-demand shock increases prices and output in the short run. A flexible exchange rate regime can partially offset the rise in aggregate demand by appreciation, and therefore the effect of the shock on output is relatively smaller.

*Is there evidence from Hong Kong to suggest that the effect of aggregate demand shock on output is smaller under flexible exchange rates than under fixed exchange rate regimes?*

First of all, the figures show that a positive aggregate demand (inflation) shock does increase prices and output in both models in the short run. Second, evidence in Figures 2-12 and 2-13 do suggest that the effect of aggregate demand shock on output is smaller under flexible exchange rates than under fixed exchange rate regimes, although evidence in the crisis-adjusted model in Figure 2-14 does not support the conclusion.

One of my essential findings is the speed in which the economy returns to steady-state after an output shock or inflation shock. The speeds of adjustment are significantly different across exchange rate regimes. In the free-floating model, both output growth and inflation return to steady-state after one standard deviation of both shocks in the fifth quarter. On the contrary, in two currency-board models, output growth and inflation return to steady-state relatively slowly. They need about eight quarters to return to steady-states. This finding suggests that a free-floating regime can cushion demand and supply shocks better than a currency board regime. The intuition behind can be explained by the economic theory that flexible exchange rate regimes can partially offset these shocks by appreciation, and therefore return to steady state will be much faster. However, under a currency board regime, after a major external demand shock, the economy can only adjust itself by altering (increasing) its price levels and wages, which is not as flexible as exchange rate movement because of price stickiness and wage rigidity in the short run. By the same token, when there is a negative supply shock (or demand shock) to the economy, Hong Kong can not depreciate her nominal exchange rate under the currency board regime. Therefore, a long but painful process of price and wage decrease is necessary for the economy to recover. These findings is one of the valid answers of my second research question, ‘why the recovery of Hong Kong from the Asian financial crisis lasted longer than other Asian countries with flexible exchange rate regimes?’

When I compare Tables 2-7 and 2-8 in the variance decomposition analyses, evidence also suggests that both output growth and inflation response are more sensitive to counterpart shocks in a currency board regime. For example, aggregate supply shocks can explain around 36% of the variance on inflation in the pre-crisis currency board model. The same
variance drops significantly to about 12% in the free-floating model. These findings are consistent with IRFs plots.

2.5.3 Sacrifice ratio analysis

2.5.3.1 Introduction

Cecchetti & Rich (2001) compute the US sacrifice ratios from three different VAR models. The ratios investigate the cumulative output loss arising from a reduction in inflation in the short run. Central bankers are interested in the ratio when they use interest rate tools to balance output growth and inflation in the conduct of monetary policy. Although Hong Kong has adopted a currency board regime since October 1983 in which Hong Kong’s interest rate has to follow the US counterpart closely, the ratio under the regime is still of value. It reveals the relationship between output growth and inflation, as a result of fixing the nominal exchange change rate against the US dollar. Moreover, it is also valuable to compare the ratios under the flexible and fixed exchange rate regimes for Hong Kong.

From equation (2.4.5) and equation (2.4.6), I can write my VMA model as follows:

\[
\begin{bmatrix}
\Delta y_t - \Delta y \\
\Delta \pi_t - \Delta \pi
\end{bmatrix} =
\begin{bmatrix}
\sum_{j=0}^{\infty} a_{11}^{(j)} e_{11}^{(j)} + \sum_{i=0}^{\infty} a_{12}^{(i)} e_{12}^{(i)} \\
\sum_{i=0}^{\infty} a_{21}^{(i)} e_{21}^{(i)} + \sum_{i=0}^{\infty} a_{22}^{(i)} e_{22}^{(i)}
\end{bmatrix}
= \begin{bmatrix}
A_{11}^{(L)} & A_{12}^{(L)} \\
A_{21}^{(L)} & A_{22}^{(L)}
\end{bmatrix}
\begin{bmatrix}
e_{1}^{(t)} \\
e_{2}^{(t)}
\end{bmatrix}.
\]

(2.5.1)

From equation (2.4.5) and equation (2.4.6), I can write my VMA model as follows:

Following the Cecchetti’s formula for the ratio, I use inflation shocks (aggregate demand shocks) to represent shifts in monetary policy, and equation (2.5.1) is convenient to examine the dynamic impact of a monetary policy shock on output growth and inflation. For inflation, the sum of the first \( \tau \) coefficient in \( A_{22}^{(L)} \) measures the impact of a monetary policy shock on its level \( \tau \) periods forward. For output growth, I will consider the cumulative effect on its level as a consequence of a monetary policy shock.

\[
S_{\pi}^{(\tau)} = \left( \sum_{j=0}^{\infty} \frac{\partial \pi_{t+\tau}}{\partial e_{\pi}^{(j)}} \right) / \left( \sum_{j=0}^{\infty} \frac{\partial \pi_{t+\tau}}{\partial e_{\pi}^{(j)}} \right) = \left( \sum_{i=0}^{\infty} a_{12}^{(i)} \right) / \left( \sum_{i=0}^{\infty} a_{12}^{(i)} \right).
\]

(2.5.2)

For a disinflation monetary policy, the numerator captures the cumulative output loss in the first \( \tau \) periods, assuming no discounting, while the denominator measures the difference in the level of inflation \( \tau \) periods afterwards. I can apply such a sacrifice ratio analysis on a free-floating regime according the the sacrifice ratio definition, however, I need to be careful to interpret the sacrifice ratio under a currency board regime. Hong Kong Monetary
Authority’s policy target is to defend the fixed exchange rate between the Hong Kong dollar and the US dollar. Therefore, the monetary policy will not consider disinflation as its priority. The ratio solely captures the relative impact of an inflation shock on output and inflation.

Under a currency board regime, in order to defend the fixed exchange rate system, HKMA has to adjust the money supply by open market operation to keep the interest rate level consistent with that of the US interest rate. For example, the Federal Reserve cuts the US interest rate to stimulate the US economy, while the interest rate in Hong Kong is relatively higher at the beginning. Market participants will buy Hong Kong dollars and sell US dollars to get a higher interest return, and create upward pressure on the exchange rate of HK dollar. Consequently, the HKMA has to stabilise the foreign exchange market by selling HK dollars to the market. The money base is increased and the local interest rate drops to match the interest rate of the US dollar. Therefore, it does not necessarily represent that the central bank HKMA utilizes the monetary policy tools to stabilise output growth and inflation. In order to defend the fixed exchange rate, HKMA has to ‘create’ some inflation shocks that will have an impact both on output growth and inflation, and the sacrifice ratio can capture the impact of those inflation shocks.

2.5.3.2 Comparing the sacrifice ratio estimates among three SVAR models

Results of the sacrifice ratio are listed in Tables 2-10 and 2-11. Meanwhile, I compute the median and 90% confidence intervals of the sacrifice ratios for the SVAR models in Matlab using bootstrap methods. Remember that in section 2.5.2 I have used Matlab to compute the impulse response function and the 90% standard error of the impulse response function following Runkle (1987). I use those data to compute the sacrifice ratio confidence intervals according to the equation (2.5.2).

![Table 2-10 Sacrifice ratio analysis for Hong Kong](image)

Source: author’s estimation.
Table 2-11 The mean and 90% confidence intervals of the sacrifice ratios

<table>
<thead>
<tr>
<th>Quarters</th>
<th>Median</th>
<th>90% confidence intervals (bootstrap methods)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>-0.6077</td>
<td>-1.8697</td>
</tr>
<tr>
<td>8</td>
<td>-0.7215</td>
<td>-4.017</td>
</tr>
<tr>
<td>12</td>
<td>-0.863</td>
<td>-6.0696</td>
</tr>
<tr>
<td>16</td>
<td>-0.9746</td>
<td>-8.1271</td>
</tr>
<tr>
<td>20</td>
<td>-1.1232</td>
<td>-10.209</td>
</tr>
<tr>
<td>Currency board regime (pre-crisis 1984-1996)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-1.5502</td>
<td>-3.4031</td>
</tr>
<tr>
<td>8</td>
<td>-1.948</td>
<td>-5.963</td>
</tr>
<tr>
<td>12</td>
<td>-2.3619</td>
<td>-8.6882</td>
</tr>
<tr>
<td>16</td>
<td>-2.8451</td>
<td>-11.4753</td>
</tr>
<tr>
<td>20</td>
<td>-3.289</td>
<td>-14.401</td>
</tr>
<tr>
<td>Currency board regime (crisis-adjusted 1984-2007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-0.4227</td>
<td>-1.7177</td>
</tr>
<tr>
<td>8</td>
<td>-0.4386</td>
<td>-3.3512</td>
</tr>
<tr>
<td>12</td>
<td>-0.4345</td>
<td>-5.1573</td>
</tr>
<tr>
<td>16</td>
<td>-0.4368</td>
<td>-6.9766</td>
</tr>
<tr>
<td>20</td>
<td>-0.4873</td>
<td>-8.7962</td>
</tr>
</tbody>
</table>

Source: author’s estimation.

Are the sacrifice ratio analyses consistent over time and across SVAR models? The sacrifice ratios for Hong Kong are consistent over the periods I examine. For instance, the sacrifice ratio for the free-floating model in table 2-10 is approximately -0.59 in the fourth quarter, while it is approximately -0.58 in the twentieth quarter. Moreover, the sacrifice ratios are all negative in three SVAR models with acceptable confidence intervals (compared with those in Cecchetti’s paper).

What does the aggregate supply and demand framework suggest on the sacrifice ratio? The framework suggests a positive ratio. A positive aggregate demand shock increase output and price level in the short-run in Figure 2-18. The cumulative output growth in the numerator is positive and the sum of the inflation in the denominator is also positive.
Are the sacrifice ratio analyses consistent with the IRFs analyses? Why are the ratios for Hong Kong negative? Yes, they are consistent with my impulse response analyses in all my SVAR models, both for the free-floating and the currency board regimes. In figures 2-12, 2-13 and 2-14, output growth turns negative in the first quarter then immediately moves to positive growth in the second quarter, however, inflation keeps a positive response after an inflation shock in that period. The overall effect on output growth tends to be positive, and consistent with the aggregate supply and demand framework. The framework indicates the overall effect of a positive aggregate demand shock on output growth and inflation, while the IRFs divide the overall shock effect into quarterly responses.

According to Cecchetti’s formula to calculate the sacrifice ratio, output is computed on the cumulative basis, which means the first quarter negative number will be counted repeatedly for most of the times (τ times according to equation (2.5.2)), but the following positive numbers are counted less times than the first negative number. The sum of the numerator turns out to be negative, and the denominator is positive. Therefore, the ratios for Hong Kong are negative in three SVAR models.

Furthermore, I notice that the sacrifice ratios in the pre-crisis currency board model are much larger in terms of absolute value, compared with those in the free-floating regime, although the ratios for the crisis-adjusted currency board model are smaller in terms of absolute value. The pre-crisis model is more reliable for the comparison.

Is there evidence from Hong Kong to suggest that the effect of aggregate demand shock on output is smaller under flexible exchange rates than under fixed exchange rate regimes? In conclusion, I contribute to the literature by introducing the sacrifice ratio analyses to Hong Kong. My evidence does suggest that the ratio is larger (in absolute value) in the currency board period than that in the free-floating period, based on evidence from
the pre-crisis model. This evidence reveals that output will react to the aggregate demand shocks in a more volatile way under a fixed exchange rate regime.

2.5.3.3 Comparing my sacrifice ratio estimates with Cecchetti’s model

In Cecchetti and Rich (2001), the authors estimate the sacrifice ratios in the US on three different VAR models, namely Cecchetti model, Shapiro-Watson model and Gali model. All three model estimates are positive but their lower confidence intervals are all negative. The Cecchetti’s model is a two-variable system, while the Shapiro-Watson and Gali models have three and four endogenous variables in their SVARs. Cecchetti and Rich reveal that the sacrifice ratios are relatively stable in Cecchetti’s model, while those ratios in the other models are somewhat too large and difficult to interpret in a reasonable sense. Therefore, I should focus my comparison on the sacrifice ratio in the Cecchetti’s model.

The ratio in Cecchetti’s model is approximately 1.3 over 20 periods, with relatively small confidence intervals. I analyse the reason why Cecchetti’s sacrifice ratio is positive by looking at the IRFs of the model. In their model, output growth has been negative after a negative aggregate demand (inflation) shock for five quarters. Consequently the shock generates a cumulative negative effect on output growth. Meanwhile, the shock also depresses the inflation to a negative 1% region across the horizons. Both the numerator and the denominator are negative; therefore the authors generate positive sacrifice ratios. Cecchetti’s results are also consistent with the IRFs analyses and the aggregate supply and demand framework.

I wish to point out the difference in model specifications between my SVAR models and those in Cecchetti’s paper. Following Bayoumi & Eichengreen (1994) and Kwan & Lui (1995, 1999), I use quarter-to-quarter difference data to generate both output growth and inflation in this empirical study. Cecchetti & Rich (2001) use quarter-to-quarter difference data to generate output growth, but use year-to-year difference data to generate an inflation series. The difference the generation of inflation data may affect the results of the sacrifice ratio analysis.
2.6 Counter-factual simulation analysis for questions three and four

The purpose of my counterfactual simulation analysis is to find quantitative evidence to answer the remaining questions.

- Which regime performs better in Hong Kong in terms of macro economy stability?
- What performance would the economy have delivered during 1974 and 1983 if a currency board regime were implemented? On the contrary, how would the economy perform during 1984-1996 if a free floating regime were chosen?

2.6.1 Methodology

My counter-factual simulation analysis will be based on the free-floating model and the pre-crisis currency board model. I will exclude the crisis-adjusted currency board model for a few reasons. First, the crisis-adjusted currency board model has been affected by the Asian financial crisis and has been adjusted by artificial crisis dummy regression. I am not sure how the estimated parameters have been affected by these factors. Second, the pre-crisis currency board model has 52 observations, which is comparable to the free-floating model in order to make a fair counter-factorial analysis. Third, I can make a fair comparison with the literature given Kwan and Lui’s models cover similar periods.

After I estimate UVAR models, I also save the residual series matrix for the free-floating and currency board regimes. I plug in one residual series matrix in its counterpart UVAR model to do a hypothetical simulation. For instance, I can use the free-floating UVAR model and the residual series matrix of the currency board model to simulate the data of a hypothetical free-floating regime for the currency board period (1984Q1-1996Q4). In such a simulation, the residual series matrix is used to represent shocks (both output and
inflation shock) happening during the study period. Note: One can also use the SVAR model and the recovered structural residual series matrix to do counter-factual simulation; the simulation results will be exactly the same according to the equations in section 2.3.

2.6.2 Free floating counter-factual simulation in the currency board period

In the free floating counter-factual analysis, I find that the actual output growth data have a much higher standard deviation than my simulation data in table 2-13. If a free-floating regime were implemented from 1984 to 1996, the output growth standard deviation would be approximately three percent, which is half of the standard deviation of my actual data. On the other hand, the simulation inflation data has relatively higher standard deviation, which is approximately 1.84. The actually inflation data has a standard deviation of 1.24. Evidence also suggests the similar patterns in fluctuation in the data plots of output growth and inflation.

**Table 2-13 Statistics for the free-floating counter-factual simulation (1984Q1-1996Q4)**

<table>
<thead>
<tr>
<th></th>
<th>Output growth (quarter-to-quarter)%</th>
<th>Inflation (quarter-to-quarter)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated data under free floating (cfgy01)</td>
<td>Actual data under currency board (gy01)</td>
<td>Simulated data under free floating (cfpai01)</td>
</tr>
<tr>
<td>Mean</td>
<td>1.65561154</td>
<td>1.09108752</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>3.00574951</td>
<td>6.23100113</td>
</tr>
<tr>
<td>Minimum</td>
<td>-8.1776</td>
<td>-11.5794963</td>
</tr>
<tr>
<td>Maximum</td>
<td>7.4466</td>
<td>12.5763464</td>
</tr>
<tr>
<td>Count</td>
<td>52</td>
<td>52</td>
</tr>
</tbody>
</table>

Source: author’s estimation.

**Figure 2-19** Free-floating counter-factual analysis (output growth)

Source: gy01 data come from HK C&S Department and cfgy01 data come from author’s estimation.
Based on the simulated data of output growth and inflation, I can recover the simulated data of log GDP per capita (log y) and log price. Evidence in figures 2-21 and 2-22 reveals that the both of them will achieve a higher level if a free-floating regime were implemented from 1984 to 1996. For instance, the hypothetical log GDP per capita will reach 10.95 at the fourth quarter of 1996, while the actually log GDP per capita only reaches 10.66. Similar situations can be found in the log price plot. If a free-floating regime were implemented, the log price level would reach about 5 at the end of 1996. The actual log price level only reached 4.81 at that period.

**Figure 2-21 Free-floating counter-factual analysis (recovered log GDP per capita)**

Source: ly data come from HK C&S Department and cfly data come from author’s estimation.
2.6.3 Currency board counter-factual simulation in the free-floating period

In the currency board counter-factual analysis, evidence in table 2-14 denotes that the actual output growth data has a noticeably smaller standard deviation than the simulation data. If the currency board were implemented from 1974 to 1983, the output growth standard deviation would be around seven, while my actual output growth in the free-floating period only has the standard deviation of 4.71. On the other hand, the simulation inflation data have relative smaller standard deviations, which are approximately 2.06. The actual inflation data has a standard deviation of 2.31.

Table 2-14 Statistics for the currency board counter-factual simulation (1974Q3-1983Q3)

<table>
<thead>
<tr>
<th>Output growth (quarter-to-quarter)%</th>
<th>Inflation (quarter-to-quarter)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated data under currency board (cfgy01)</td>
<td>Simulated data under currency board (cfpai01)</td>
</tr>
<tr>
<td>Mean</td>
<td>0.926686111</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>7.081244236</td>
</tr>
<tr>
<td>Maximum</td>
<td>12.0559</td>
</tr>
<tr>
<td>Count</td>
<td>36</td>
</tr>
</tbody>
</table>

Source: author’s estimation.

Figure 2-22 Free-floating counter-factual analysis (recovered log price data)
Source: gy01 data come from HK C&S Department and cfgy01 data come from author’s estimation.

Source: pai01 data come from HK C&S Department and cfpai01 data come from author’s estimation.

Based on the simulated data of output growth and inflation, I also recover the simulated data of log GDP per capita and log price for the free-floating period. Evidence in figures 2-25 and 2-26 suggests that the both of them are slightly higher than the actual data in the first half of the simulation period. However, they will achieve a relatively lower level if a currency board regime were implemented in the second half of the simulation period.

Source: ly data come from HK C&S Department and cfly data come from author’s estimation.
2.6.4 Common findings in the two counter-factual simulations

When comparing the above two counter-factual analyses, evidence reveal that the following results are consistent across the two periods. First, the currency board regimes tend to have noticeably higher output growth standard deviations than free-floating regimes. Second, the free-floating regimes have marginally higher inflation standard deviations compared with the currency board regimes. The differences in the standard deviations are in small scale. Third, free-floating regimes will lead to both GDP per capita and price level reaching higher levels at the end of the periods I am concerned with.

2.6.5 Comparing my counter-factual simulation analyses with those of Kwan and Lui’s study

- Different results in the standard deviations analysis.

In Kwan and Lui’s paper, they find the currency board regimes both have relatively smaller standard deviations in output growth. However, I find evidence that those currency board regimes have noticeably larger standard deviations.

In my two UVAR models, I include seasonal dummies in the exogenous section, and I am not supposed to make the seasonal adjustment in my endogenous variables (output growth and inflation). Although this method will increase the complexity in my SVAR modeling and the counterfactual simulation, it proves to be more reliable. On the contrary, Kwan and Lui use a spectral method to deseasonalize their data before they conduct their counter-factual analysis. However, the deseasonalizing procedure itself has artificially changed the standard deviation of those endogenous variables. And the estimated parameters and the residuals (shocks) are computed based on those adjusted data.

Figure 2-26 Currency-board counter-factual simulation (recovered log price)

Source: lp data come from HK C&S Department and cflp data come from author’s estimation.
Therefore, it is difficult to estimate how many changes have been made to the ‘actual data’ for comparison and the counter factual data. Note that my computed standard deviations are noticeably larger than Kwan and Lui’s figures because seasonal variations are included in my statistics while Kwan and Lui’s results have excluded such factors.

Table 2-15 Statistics for Kwan and Lui’s counter-factual simulation

<table>
<thead>
<tr>
<th>NOTE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>This table is included on page 57 of the print copy of the thesis held in the University of Adelaide Library.</td>
</tr>
</tbody>
</table>


- Similar results in recovering log GDP per capita and log price

In my free-floating counter-factual simulation, I find that both the recovered log GDP per capita and log price would achieve levels higher than the actual data (currency board regime) if a free-floating regime were implemented from 1984 to 1996. Moreover, in my currency board counter-factual simulation from 1974 to 1983, the two simulated series are slightly higher than the actual data in the first half of the simulation period; however, they will achieve a relatively lower level if a currency board regime were implemented in the second half of the simulation period. Therefore, in both of my counter factual simulations, results suggest that a free-floating regime tends to make the log output and log price reaching high levels.

Kwan and Lui also find similar results in which a free-floating regime will perform better in terms of higher levels in output and inflation. However, they did not find evidence that in a currency board counter-factual simulation from 1974 to 1983, the simulated output and inflation series are first slightly higher than the actual free floating data in the first half of the simulation period, and then fall to a relatively lower level than the actual data in the second half of the simulation period. Their results suggest that the simulated data series (currency board) have been consistently lower than the actual data (free-floating).

In conclusion, evidence in my counter-factual analyses indicates that free-floating regimes achieve more satisfactory performance in terms of lower variation in output growth, and higher levels in output and price.
2.7 Major findings and conclusions

In this chapter, I have examined Hong Kong’s economy under different exchange rate regimes, and found empirical evidence to answer the following set of research questions.

*Is there evidence from Hong Kong to suggest that the effect of aggregate demand shock on output is smaller under a flexible exchange rate than under a fixed exchange rate regime? Is this one of the major reasons why the recovery process of Hong Kong from the Asian financial crisis lasted longer compared with other Asian countries with a flexible exchange rate regime?*

Following Bayoumi & Eichengreen (1994), I have chosen the output growth rate and inflation rate as explanatory variables in my first empirical model, and identified unrestricted VAR models on data from both the free-floating and currency board periods. I apply the Banchard and Quah restrictions (neutrality of money in the long-run) as the extra restrictions to recover my structural parameters. Furthermore, I follow Cecchetti’s model to release the unitary assumption in the structural residual matrix. While the Kwan & Lui (1996, 1999) models assume unitary variances in the error terms to recover their structural parameters, my empirical results show that the variances of error terms are considerably greater than one.

In the impulse response functions (IRFs) and variance decomposition analysis, I have first compared the unrestricted VAR and structural VAR models for the free-floating period. Evidence suggests that results are significantly different in the two models. The response of output growth to an aggregate demand shock has changed noticeably compared to that of the UVAR model. And the variance decomposition analysis also indicated the difference between these two models quantitatively. I analyse the importance of recovering the SVAR parameters. Second, I have compared IRFs and variance decomposition of the pre-crisis currency board model and the crisis-adjusted model. I find evidence that the pre-crisis model captures the economy better in both cases and therefore I select it as the baseline model for the currency board period. Third, I have illustrated that the IRF analysis is consistent with the aggregate supply and demand framework.

Fourth, I have compared the free-floating and currency board SVAR models in details. I find convincing evidence to answer my first research question. Figures in the IRFs show that a positive aggregate demand (inflation) shock does increase prices and output in all
SVAR models in the short-run. Moreover, evidence from IRFs suggest that the effect of aggregate demand shock on output is smaller under flexible exchange rates than under fixed exchange rate regimes, although evidence from the crisis-adjusted model does not support the conclusion.

One of my interesting findings is the speed in which the model returns to steady-state after an output or inflation shock. Evidence suggests that the speeds of after-shock adjustment are significantly different across exchange rate regimes. I find that in the free-floating model, both output growth and inflation return to steady-state in a much shorter period. This finding suggests that a free-floating regime can cushion demand and supply shocks better than a currency board regime. The above findings provide a valid reason why the recovery process from the Asian financial crisis was much longer in Hong Kong as compared with the other Asian countries with a flexible exchange rate regime. These findings have not yet been reported in the literature I examined.

I have applied the sacrifice ratio analysis, which provides a quantitative measurement of the cumulative output change on the inflation gained after a positive demand shock. Furthermore, I also apply the bootstrapped method to compute the confidence intervals of the sacrifice ratio in order to provide convincing comparisons. The sacrifice ratios for Hong Kong are consistent over the periods I examine. Moreover, the sacrifice ratio is all negative (around -0.58, -1.23, -0.38) in the three SVAR models, with acceptable confidence intervals (compared with those in Cecchetti’s paper).

According to the aggregate supply and demand framework, a positive aggregate demand shock increases output and price level in the short-run. Following Cecchetti’s sacrifice ratio formula, the cumulative output growth in the numerator is positive and the sum of the inflation in the denominator is also positive. The framework suggests a positive ratio.

I have checked these ratios with the impulse response analyses in all my SVAR models, and found that they are consistent. Moreover, I analyse the reason why the ratios are negative in my SVAR models. The framework shows the overall effect of a positive aggregate demand shock on output growth and inflation; the IRFs divide the overall shock effect into quarterly responses. According to Cecchetti’s formula to calculate the sacrifice ratio, output is computed on a cumulative basis, which means the first quarter negative number will be counted repeatedly for most of the times, but following positive numbers are counted fewer times than the first negative number. The sum of the numerator turns
out to be negative, and the denominator is positive. Therefore, the ratios for Hong Kong are negative in three SVAR models for Hong Kong.

Furthermore, evidence denotes that the sacrifice ratios in the pre-crisis currency board model are much larger in terms of absolute value, compared with those in the free-floating regime, although the ratios for the crisis-adjusted currency board model are smaller in terms of absolute value. The pre-crisis model is more reliable for the comparison.

In Cecchetti & Rich (2001), they estimate the sacrifice ratios in the US on three different VAR models. I focus my comparison on the sacrifice ratio in on a major model, called the Cecchetti’s model. The ratio in Cecchetti’s model is about 1.3 over 20 periods, with relatively small confidence intervals. I analyse the reason why Cecchetti’s sacrifice ratio is positive by looking at the IRFs of the model.

In conclusion, I have contributed to the literature by introducing the sacrifice ratio analyzes to study Hong Kong’s economy. My evidence does show that the ratio is larger (in absolute value) in the Currency board period than that in the free-floating period, based on the evidence from the pre-crisis model. This evidence suggests that output will react to the aggregate demand shocks in a more volatile way under a fixed exchange rate regime.

Which regime would have performed better in Hong Kong in terms of macro economy stability when I do a historical comparison of the free-floating period and the currency board period? What performance would the economy have delivered during 1974 and 1983 if a currency board regime had been implemented? On the contrary, how would the economy have performed during 1984-1996 if a free-floating regime had been chosen?

In my counter-factual analyses, I have included seasonal dummies in the exogenous section, and it is not necessary to conduct seasonal adjustments in my endogenous variables (output growth and inflation). Both counter-factual analyses indicate that under free-floating regimes, the fluctuations of output growth have been noticeably reduced, while the inflations are marginally higher. Moreover, a free-floating regime generates higher levels of log output and log price in the counter-factual analysis. I also compare my findings with Kwan and Lui’s model. In Kwan and Lui’s model, they find that currency board regimes generates smaller standard deviations in output growth and inflation; meanwhile, they also find that free-floating regimes make the log output and log price both achieve higher levels. I analyse the limitation in Kwan and Lui’s model and justify my findings.
In conclusion, empirical evidence suggests that output responded to an aggregate demand shock much faster in a flexible exchange rate regime than in a fixed exchange rate regime. The evidence provides one of the essential reasons why the recovering process of Hong Kong from the Asian financial crisis lasted longer compared with the other Asian countries with a flexible exchange rate regime. Furthermore, my counter-factual analysis suggests that a free-floating regime does generate much smaller output variance in Hong Kong and delivers higher output and price levels.
Chapter 3
Comparing two macroeconomic models of Hong Kong during the currency board period (1984-2007): considering the impacts of the US and the Chinese economy on Hong Kong

3.1 Introduction
In chapter two, I have conducted a historical comparison of the free floating exchange rate regime and the fixed regime under a Currency Board in Hong Kong. Assuming that foreign factors remain stable during those two regime periods, I only investigate the domestic output growth and inflation in Hong Kong while paying limited attention to study the impact of foreign demand and supply factors on the economy.

As a small open economy, Hong Kong relies significantly on the macroeconomic environment of its major trading partners, such as the United States and Mainland China. As I discuss in chapter one, the nominal exchange rate of the Hong Kong dollar has been fixed with the US dollar since 1983. Under such an arrangement, Hong Kong’s short-term and long-term interest rates have to move closely with those in the US. Moreover, the United States has been one of Hong Kong’s major trading partners in the past two decades. Therefore, it is essential to analyse the impact of the US economy on Hong Kong when I attempt to model Hong Kong’s economy via a structural VAR framework of aggregate demand and aggregate supply.

Mainland China and Hong Kong have been fortifying their close economic link since China opened its door to the world and commence to participate in world trade in 1978. As an international entrepot trade and financial service centre, Hong Kong has been playing a significant role in facilitating China’s trade with the rest of the world. The link between the two economies has been further strengthened after the handover year of 1997 and the year 2001 when China joined the World Trade Organization (WTO) and became one of the major international trade participants. Moreover, since 2003, a series of Closer Economic Partnership Agreements (CEPA) have been signed by the Hong Kong SAR and the Central Government of China. Under CEPA agreements, barriers on merchandise and services trade have been removed and some economic stimulation policies are being implemented.
Chapter 3

to encourage more resources to flow to Hong Kong, such as the Individual Visit Scheme (IVS). According to a legislative council study on the impact of CEPA on the Hong Kong economy, more than 34,000 new jobs have been created during the first three years of CEPA, from 2004 to 2006. Details of the figures are illustrated as follows:

Table 3-1

NOTE:
This table is included on page 63 of the print copy of the thesis held in the University of Adelaide Library.

Source: June reports from Commerce, Industry and Technology Bureau of Hong Kong.

Therefore, it is also important to include the Chinese factors in my empirical model, which studies Hong Kong’s output growth and inflation.

Research Questions

(1) What are the major exogenous variables which deliver the impact of the US economy on Hong Kong?
(2) What are the key exogenous variables which can capture the close economic relationship between Mainland China and Hong Kong SAR?
(3) Which of my two macroeconomic models best captures the impact of external demand and supply on Hong Kong’s economy?

3.2 Methodology

The aim of this chapter is to identify the major variables which can capture the impact of external demand and supply on Hong Kong and reveal the importance of the international trade sector. I first select the proper US data to represent external demand and supply and use these data as exogenous variables in my unrestricted VAR (UVAR) model. I subsequently analyse how much extra explanatory power is generated by these variables, when compared with the baseline model in chapter two, which does not consider the impact of foreign factors on Hong Kong’s economy. Second, I use the Chinese entrepot trade related data and Wholesale Price Index data (WPI) as exogenous variables to
estimate the parameters of another UVAR model. I also examine how much extra explanatory power I can achieve in that model by adding these exogenous variables. Finally I compare these two UVAR models, and choose the one that can better capture the impacts of external demand and supply factors on Hong Kong’s economy. I recover the structural VAR parameters for THE model and conduct further SVAR analyses, such as impulse response functions, variance decomposition and sacrifice ratio. I attempt to investigate whether these features have been changed significantly compared to the baseline SVAR model, which does not consider any external demand and supply factors.

A structural VAR model with exogenous variables

Equation (2.4.2) can be augmented to take account of exogenous variables:

\[
B_0 X_t = C + B_1 X_{t-1} + B_2 X_{t-2} + \cdots + B_n X_{t-n} + A Z_t + E_t, \tag{3.2.1}
\]

Here \(X_t\) are domestic demand and supply variables, which are endogenous; \(Z_t\) are exogenous variables representing external demand and supply. \(E_t = [\varepsilon_t^y, \varepsilon_t^x]^	op\) is a vector innovation process that contains shocks to aggregate supply (\(\varepsilon_t^y\)) and aggregate demand (\(\varepsilon_t^x\)).

The structural VAR cannot be directly estimated, given that the error term is correlated with the contemporary explanatory variables. However, I can recover the structural VAR from an unrestricted VAR system, which has the following form:

\[
X_t = CC + D_1 X_{t-1} + D_2 X_{t-2} + \cdots + D_n X_{t-n} + AA Z_t + U_t. \tag{3.2.2}
\]

Detailed procedure of recovering the structural VAR model from an unrestricted VAR is demonstrated in section 2.4 of chapter two. Moreover, I will apply those Matlab codes in chapter two to analyse the SVAR features such as impulse response functions, variance decomposition and sacrifice ratios for further investigation.

3.3 Literature review

I follow chapter two’s major literature sources such as Cecchetti and Rich (2001), Kwan and Lui (1999)’s SVAR framework to carry out empirical modelling in this chapter. Most of the literature on output growth and inflation structure has been reviewed in chapter two,
so I avoid repeating those literature reviews. Here I focus on new literature which is relevant to my research questions in this chapter.

There are some references only discussing the impacts of the US economy or the Chinese economy on Hong Kong’s output growth, or the macro economy. Although no further empirical analysis has been provided, there are some good points in those references.

Song and Wong (1998) discuss the three major Chinese factors which have significant impact on Hong Kong’s output growth: foreign direct investment, entrepot trade and Chinese immigration. Ha and Leung (2002) discuss the implications of the US interest rate for Hong Kong. In their paper, they show the transmission mechanism of the US interest rate on Hong Kong’s output as well as the transmission mechanism of other channels, such as real exchange rate, demand shocks and supply shocks:

*Figure 3-1*

![Figure 3-1](image-url)

**NOTE:**
This figure is included on page 65 of the print copy of the thesis held in the University of Adelaide Library.

*Source: Ha & Leung (2002)*

In general, these two papers indicate some good external variables which might play a significant role in Hong Kong’s economy, affecting output growth and/or inflation.

There are also some references that study some economies’ impacts on Hong Kong’s output growth in a structural VAR model, however, they are less convincing in that they omit Hong Kong’s inflation in their empirical model. It is important to analyse Hong Kong’s economy in an output growth and inflation structure, given that the former represents the domestic aggregate demand and the latter captures the domestic aggregate supply.
Cosby (2000) studies Hong Kong’s output in a three-variable SVAR model: the change in real oil price, the change in federal funds rate, and Hong Kong’s output growth. The author uses the first variable to capture exogenous real shocks on Hong Kong’s economy, the second variable to pick up the impact of foreign monetary shocks and the last variable to capture monetary, fiscal and another forces that affect Hong Kong GDP. The author finds that the change in real oil price is not doing a very good job at picking up the impact of foreign real shocks on the Hong Kong economy, while the change in federal funds rate do have an effect on Hong Kong’s output. Cheung (2000) studies Hong Kong’s output dynamics in a three-variable Vector Error Correction Model (VECM): output growth data from Hong Kong, Japan and the US. A VECM model is the modification of a UVAR model with common long run trends. The author finds no consistent evidence to suggest that the US influence is stronger than the Japanese one, although the US dollar is the anchor currency of the Hong Kong Linked Exchange Rate System (LERS, also called the Currency Board Arrangement). The author also extends the model with trade and financial variables, and finds that the additional variables provide incremental explanatory power. Cosby and Cheung’s papers do not attempt to study the impacts of the Chinese economy on Hong Kong’s output growth. The above two papers have excluded Hong Kong’s inflation in their SVAR or VACM, which plays an essential role in explaining the output dynamics.

The most relevant literature to my empirical framework can be found in Genberg, Liu and Jin (2006). The authors attempted to model the US, China and Hong Kong economies in one SVAR model and to analyze the impact of US and Chinese economy on Hong Kong by looking at the variance decomposition. Their structural model specification (VMA) is defined as follows:

\[
\begin{pmatrix}
\Delta y_{t}^{US} \\
\Delta p_{t}^{US} \\
TB_{t}^{US} \\
\Delta y_{t}^{CN} \\
\Delta p_{t}^{CN} \\
\Delta y_{t}^{HK} \\
\Delta p_{t}^{HK}
\end{pmatrix} = 
\begin{pmatrix}
1 & a_{12} & a_{13} & 0 & 0 & 0 & 0 \\
0 & 1 & a_{21} & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & a_{31} & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & a_{41} & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & a_{51} & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & a_{61} \\
0 & 0 & 0 & 0 & 0 & 0 & 1
\end{pmatrix}
\begin{pmatrix}
e_{t}^{US}_{yt} \\
e_{t}^{US}_{yt} \\
e_{t}^{US}_{yt} \\
e_{t}^{CN}_{yt} \\
e_{t}^{CN}_{yt} \\
e_{t}^{CN}_{yt} \\
e_{t}^{CN}_{yt}
\end{pmatrix}
\]

(3.3.1).

They recover their structural parameters by imposing \( a_{12} = a_{13} = a_{21} = a_{45} = a_{66} = 0 \) restrictions, which have the following hypothetical implications:
(a) US inflation and Treasury bonds together will have zero impact on the US output growth in the long run (money neutrality assumption);
(b) Treasury bonds will have zero impact on the US inflation in the long run;
(c) Chinese inflation has zero impact on Chinese output growth in the long run (money neutrality assumption);
(d) Hong Kong inflation has zero impact on her output growth in the long run (money neutrality assumption);

The money neutrality assumptions (also called the Banchard and Quah restriction) have been commonly used in literature and I also applied these assumptions to my empirical model. Therefore I accept implications (a), (c) and (d). However, I could not accept implication (b) that Treasury bonds will have zero impact on the US inflation in the long run. This assumption is inconsistent with the Federal Reserve’s Open Market Operation in which the Federal Reserve will buy or sell Treasury bonds to market participants in order to adjust money supply and keep the inflation rate under their target range.

Furthermore, Genberg, Liu and Jin’s model put zeros on the upper diagonal of the Vector Moving Average (VMA) representation, which simplifies the model in some way. However, their model specification consequently brings three more hypothetical implications:
(i) Both the China and Hong Kong economies have zero impact on the US counterpart in the long run;
(ii) The US economy affects Chinese economy, but Hong Kong’s economy has no impact on Chinese economy;
(iii) Hong Kong’s economy is influenced by both the US and Chinese economy.

Implication (i) and (ii) are obviously inconsistent with the real situation among the three economies. Mainland China is one of the United States’ major trading partners and the Chinese Central bank (People’s Bank of China) holds the largest amount of foreign reserve, most are US treasury bonds. Moreover, Hong Kong has been a top FDI provider in China for decades. Such a VMA representation has contributed to one of the paper’s major findings in their variance decomposition that US shocks (three-combined) have explained 61% and 45% of Hong Kong’s output and price variations. Interestingly, their model shows that Chinese shocks (two-combined) can only explained 8% of Hong Kong’s output variation, but can explain 36% of Hong Kong’s inflation variation. Hong Kong’s domestic shocks (two-combined) explain the remaining 31% and 19.5% of the output and inflation variation. However, these variance decomposition results depend heavily on the arbitrary
model specification and can be inconsistent with the real economic situation in Hong Kong. Therefore, their findings could provide limited policy implications. Admittedly, the purpose of my study is somewhat different to that of Genberg et al (2006), although both consider the impacts of the US and the Chinese Economy on Hong Kong.

3.4 Model I: considering impact of the US economy on Hong Kong

3.4.1 Preliminary analysis

I first examine the short term interest rate movements between Hong Kong and the United States. In a theoretical model of fixed exchange rate regime, these two rates should move very closely, due to the mechanism of Covered Interest Parity (CIP). The historical data supports this theory in most time frames, except those quarters in 1987, 1998 and 1999 when financial markets were in a turbulence situation. For example, during the Asian financial crises period (1998-1999), the mechanism linking the two interest rates together switched from CIP to UIP (Uncovered Interest Parity) as market participants doubted the sustainability of the fixed exchange rate regime and sold their Hong Kong dollar for the US dollar to the Hong Kong Monetary Authority in substantial scale. Consequently, the supply of base money decreased and the interest rate in Hong Kong had to move significantly higher than the rate in the US.

Figure 3-2 Hong Kong and the US short-term interest rates

Source of data: Hong Kong C&S Department and Datastream.

I compute the correlation coefficient of the two rates from 1984 to 2007, and find that it is fairly high, as people expected. The coefficient is equal to 0.8955. Under the fixed exchange rate arrangement, I accept the assumption that interest rate in Hong Kong is exogenous and its movement has to follow the movement of the interest rate in US. Therefore, the US interest rate is one of the potential variables to explain the movement of output growth and inflation in Hong Kong.
I plot NEERs, REERs and their first difference in log values (REER changes) as follows.

**Figure 3-3 Hong Kong and the US nominal effective exchange rates (NEERs)**

![Graph of Hong Kong and the US nominal effective exchange rates](image)

Source of data: Hong Kong C&S Department and Datastream.

**Figure 3-4 Hong Kong and the US real effective exchange rates (REERs)**

![Graph of Hong Kong and the US real effective exchange rates](image)

Source of data: Hong Kong C&S Department and Datastream.

**Figure 3-5 Changes in Hong Kong and the US NEERs**

![Graph of Changes in Hong Kong and the US NEERs](image)

Source of data: Hong Kong C&S Department and Datastream.
Source of data: Hong Kong C&S Department and Datastream.

Under the Currency Board arrangement, the nominal exchange change rate of the HK dollar has been fixed with the US dollar. However, when I compute the nominal effective exchange rate (NEER) and the real effective exchange rate (REER), figures 3-3 and 3-4 reveal that they are not necessarily identical to their US counterpart, as the NEER is the trade weighted index of nominal exchange rate with all the trade partners. Hong Kong and the United States do not necessarily share the identical trade patterns. Furthermore, the REER is actually the inflation-adjusted NEER, therefore REERs from HK and US can deviate from each other. From the above two plots of NEERs and REERs, I find that the two NEERs move relatively close, while the two REERs deviate from each other most of the time. However, I notice that the movement directions of the NEERs and REERs are noticeably close.

I calculate the correlation of NEERs and REERs from the HK dollar and the US dollar, and find the correlation coefficients as follows:

Table 3-2 Correlation of NEERs and REERs

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation coefficient of NEERs</td>
<td>0.674</td>
</tr>
<tr>
<td>Correlation coefficient of NEER changes</td>
<td>0.920</td>
</tr>
<tr>
<td>Correlation coefficient of REERs</td>
<td>-0.010</td>
</tr>
<tr>
<td>Correlation coefficient of REER changes</td>
<td>0.713</td>
</tr>
</tbody>
</table>

Source: author’s estimation.

All these correlation coefficients are consistent with the observations on the data plots. Despite the negative and low correlation coefficient in the level of REERs, Evidence suggests that changes in both the NEER and REER of the HK dollar have a significantly high positive correlation with those of the US dollar. These findings can be sufficiently explained by the fixed exchange arrangement of the HK dollar with the US dollar.
Therefore, REER changes of the US can be a good exogenous variable to explain the movement of output growth and inflation in Hong Kong.

3.4.2 Description of data

- **Hong Kong data**
  
  I use the quarterly data for the currency board period (1984-2007) and apply the crisis-adjusted model as a baseline model in this chapter. As Hong Kong has significantly taken part in the international trade (direct export and re-export) with the US and Mainland China in the past ten years, therefore the pre-crisis model (1984-1997) is not a favourable choice in this chapter, while the crisis-adjusted model is preferred. The output growth and inflation data of Hong Kong are from the crisis adjusted model with the seasonal effect and the crisis impact removed. The original source of the Hong Kong data is from the Hong Kong Census and Statistics Department.

**Figure 3-7 Hong Kong output growth rate and inflation rate**

*Source of data: Hong Kong C&S Department and Datastream.*

- **The United States data**
  
  All my United States data are downloaded via Datastream. These data are at a constant price level with the seasonal effect removed. I apply US imports data and GDP deflator to generate imports growth rate and inflation rate, by taking log difference. Now, I use the imports growth and inflation as a proxy to capture the external demand and supply changes affecting Hong Kong. Moreover, I will also add interest rate movement and real effective exchange rate changes from the US in my extended models, to examine the additional effects from these variables and discover the importance of these external variables.
Before I apply all the endogenous and exogenous variables in my study, I will conduct unit-root tests to examine the stationary condition of the data. In chapter two, I have confirmed that the output growth rate and inflation rate data for Hong Kong are stationary. The following table illustrates the unit roots test results for the US data: import growth rate, inflation rate based on GDP deflator, interest rate movement and real effective exchange rate percentage changes.

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Augmented Dickey-Fuller (Lag Length: 2)</th>
<th>Phillips-Peron</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIMP (Δimp) has a unit root</td>
<td>P-value=0.0001</td>
<td>P-value=0.0000</td>
</tr>
<tr>
<td>USPAI (Δfp) has a unit root</td>
<td>P-value=0.0703</td>
<td>P-value=0.0000</td>
</tr>
<tr>
<td>MOVIN (fi − fi−1) has a unit root</td>
<td>P-value=0.0005</td>
<td>P-value=0.0000</td>
</tr>
<tr>
<td>CHREER (Δfreer) has a unit root</td>
<td>P-value= 0.0029</td>
<td>P-value=0.0000</td>
</tr>
</tbody>
</table>
The test results suggest that all four exogenous variables are stationary at 5% level of significance when I apply the Phillips-Peron test. When I examine the Augmented Dickey-Fuller results, the US inflation can only be regarded as stationary at 10% level of significance, while others can confidently be regarded as stationary at 5% level. Based on the two test results, I am justified to apply the above four exogenous variables in VAR analysis.

3.4.3 UVAR results and analysis

In order to make a comparison of my new empirical models, I repeat the crisis-adjusted UVAR model of the output growth and inflation for the currency board period (1984-2007) from chapter two. I regard it as a baseline model in this chapter as the model has not considered the impacts of any external demand and supply variables. I subsequently add relevant exogenous explanatory variables from the United States to represent the external demand and supply, and attempt to ascertain they have or have not any significant impact on Hong Kong’s economy.

- The baseline model results can be found in Specification #1 with zeros in the exogenous section \( Z_t \). In Specification #2, I first add contemporary US import growth and inflation to the exogenous section. I use the US import growth to represent the external demand factor, and use the US inflation to represent the external supply factor. I find that Specification #2 has successfully increased the adjusted \( R^2 \) for the \( \Delta y_t \) equation from 0.097 to 0.14, which means about additional 4.3% of the variation of the output growth of Hong Kong can be explained in the model by adding the contemporary US import growth and inflation data. However, this model shows a marginal decrease (0.6%) in the explanatory power for Hong Kong’s inflation.

- In Specifications #3 and #4, I also consider the lag orders of the US import growth and inflation. I find that these two models could not improve the explanatory power compared with Specification #2 for the \( \Delta y_t \) equation, while Specification #4 can marginally improve the explanatory power for \( \Delta p_t \) equation. Therefore, I prefer the contemporary US import growth and inflation in my empirical model. The intuition behind is that the US economy can deliver its full impact to Hong Kong within the same quarter (three months time).
Furthermore, I examine the impact of the US interest rate movement and the impact of the change of REER on Hong Kong. I find that an additional 2.5% of the explanatory power for Hong Kong’s output growth equation can be achieved in Specification #6 when compared to Specification #2. This finding is consistent with my preliminary analysis result, in that there is a strong correlation between the US and Hong Kong short-term interest rates, and there is also a strong correlation between the movement of the real effective exchange rates. These strong correlations are driven by the fixed exchange rate arrangement with the US dollar.

It is worthwhile to point out that adding more exogenous US explanatory variables to my study has failed to improve the explanatory power for the $\Delta p_t$ equation. These findings suggest that although the US economy does have noticeable impact on the output growth in Hong Kong, it fails to bring extra explanatory power to the inflation equation. My evidence suggests that the US economy might have little impact on inflation in Hong Kong.

### Table 3-4 Model selection I

<table>
<thead>
<tr>
<th>Model specifications</th>
<th>$X_t = CC + D_1X_{t-1} + D_2X_{t-2} + AAZ_t + U_t$</th>
<th>Adjusted $R^2$ for the $\Delta y_t$ equation</th>
<th>Adjusted $R^2$ for the $\Delta p_t$ equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1. $X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} 0 \ 0 \end{bmatrix}$</td>
<td>0.096632</td>
<td>0.049287</td>
<td></td>
</tr>
<tr>
<td>#2. $X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta \text{fimp}_t \ \Delta \text{fpt}_t \end{bmatrix}$</td>
<td>0.140101</td>
<td>0.043531</td>
<td></td>
</tr>
<tr>
<td>#3. $X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta \text{fimp}<em>{t-1} \ \Delta \text{fpt}</em>{t-1} \end{bmatrix}$</td>
<td>0.083664</td>
<td>0.036701</td>
<td></td>
</tr>
<tr>
<td>#4. $X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta \text{fimp}<em>{t-2} \ \Delta \text{fpt}</em>{t-2} \end{bmatrix}$</td>
<td>0.131787</td>
<td>0.046748</td>
<td></td>
</tr>
<tr>
<td>#5. $X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta \text{fimp}_t \ \Delta \text{fpt}_t \ \text{f}<em>t - \text{f}</em>{t-1} \end{bmatrix}$</td>
<td>0.144398</td>
<td>0.039231</td>
<td></td>
</tr>
<tr>
<td>#6. $X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta \text{fimp}_t \ \Delta \text{fpt}_t \ \text{f}<em>t - \text{f}</em>{t-1} \ \text{freer}_t \end{bmatrix}$</td>
<td>0.165442</td>
<td>0.038965</td>
<td></td>
</tr>
</tbody>
</table>
3.5 Model II: considering the close economic relationship between Mainland China and Hong Kong SAR

3.5.1 Description of data

The re-exports data to Mainland China and the re-exports to all destinations are downloaded from the Census and Statistics Department of Hong Kong. These exports data are unique for Hong Kong in that they represent a major proportion of the exports activity of Hong Kong and that they are generally regarded as ‘exogenous’. It is interesting to point out that the re-exports activity are essential to Hong Kong’s economy, which can be characterized as a small open economy with flourishing trade and service sectors. Therefore, the re-exports data can be regarded as an ideal exogenous variable which may provide good explanatory power to model the output growth and inflation dynamics for Hong Kong. Moreover, the US Wholesale Price Index (WPI) is commonly used as the index for the world price levels. The WPI data is downloaded via Datastream. These data are seasonally adjusted and meanwhile at constant price level.

*Figure 3-10 Log re-exports to Mainland China and log WPI*

![Figure 3-10 Log re-exports to Mainland China and log WPI](image)

**NOTE:**
This figure is included on page 75 of the print copy of the thesis held in the University of Adelaide Library.

*Source of data: Datastream.*

*Figure 3-11 Growth rate of re-exports to Mainland China and inflation rate*

![Figure 3-11 Growth rate of re-exports to Mainland China and inflation rate](image)

**NOTE:**
This figure is included on page 75 of the print copy of the thesis held in the University of Adelaide Library.

*Source of data: Datastream.*
Source of data: Datastream.

I apply two unit root tests to three exogenous variables. Evidence from table 3-5 suggests that these data are stationary at 5% level of significance.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
Null Hypothesis & Augmented Dickey-Fuller & Phillips-Peron \\
\hline
GMAIN( \( \Delta reex2cn \) ) has a unit root & P-value=0.0000 & P-value=0.0000 \\
GOVER( \( \Delta reex2all \) ) has a unit root & P-value=0.0001 & P-value=0.0000 \\
WPIPAI( \( \Delta wpi \) ) has a unit root & P-value=0.0028 & P-value=0.0000 \\
\hline
\end{tabular}
\caption{Unit root tests: growth rates of re-exports to Mainland China and to all destinations, and inflation rate based on US Wholesale Price Index (1984-2007)}
\end{table}

3.5.2 Preliminary analysis

I first examine the proportion of re-export destinations in the following pie-chart. China is the major destination to where 49% of the value of the mechanised goods is re-exported, while the United States, EU members, Japan and the rest of the world share the remaining 51%. The figure provides us with a clear look at the re-export activity in Hong Kong which serves as an entrepot trade centre linking China and the west of the world.
The re-export activities in Hong Kong follow two-way directions: on one hand, Hong Kong helps China to export its products to the rest of the world; on the other hand, Hong Kong also assists China to import goods from the rest of the world. The re-export data captures Hong Kong’s close economic relationship with China. Re-export activities are determined by the economies of countries outside Hong Kong, and therefore the re-exports data can be regarded as exogenous. They provide a good proxy of the external aggregate demand for goods and services from Hong Kong.

The re-exports data to Mainland China are a component part of the re-export data to all destinations. I plot the growth rates of re-export data to both regions, and find that they move in very similar patterns, as I expected. The correlation coefficient between them is
fairly high (0.797). I subsequently apply these two exogenous variables to my empirical models and investigate which of them can provide a stronger explanatory power.

**Figure 3-15 Growth rates of re-exports**

![NOTE: This figure is included on page 78 of the print copy of the thesis held in the University of Adelaide Library.]

Source of data: Hong Kong C&S Department.

### 3.5.3 UVAR results and analysis

**Table 3-6 Model selection II**

<table>
<thead>
<tr>
<th>Model specifications</th>
<th>Adjusted $R^2$ for the $\Delta y_t$ equation</th>
<th>Adjusted $R^2$ for the $\Delta p_t$ equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( X_t = CC + D_1 X_{t-1} + D_2 X_{t-2} + AA Z_t + U_t )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) ( X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} 0 \ 0 \end{bmatrix} )</td>
<td>0.096632</td>
<td>0.049287</td>
</tr>
<tr>
<td>(b) ( X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta reex2cn_t \ \Delta wpi_t \end{bmatrix} )</td>
<td>0.114733</td>
<td>0.042783</td>
</tr>
<tr>
<td>(c) ( X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta reex2all_t \ \Delta wpi_t \end{bmatrix} )</td>
<td>0.257205</td>
<td>0.062872</td>
</tr>
<tr>
<td>(b)* ( X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta reex2cn_t \ \Delta wpi_t \end{bmatrix} ) (sub-sample: exclude early volatile observations)</td>
<td>0.246913</td>
<td>0.091454</td>
</tr>
<tr>
<td>(d) ( X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta reex2all_{t-1} \ \Delta wpi_{t-1} \end{bmatrix} )</td>
<td>0.149563</td>
<td>0.039943</td>
</tr>
</tbody>
</table>

**Note:** (b)* uses the same model specification as (b) with a shorter sample period (1987Q1-2007Q4), as there are volatile observations from 1984 to 1986 in the growth of re-export data to Mainland China.
I apply a similar approach by putting the baseline model results in Specification (a) with zeros in the exogenous section \((Z_t)\). I first consider adding contemporary growth data for re-exports to Mainland China and inflation data from WPI to the exogenous section in Specification (b). I find that Specification (b) only increases its explanatory power by 1.8% for the \(\Delta y_t\) equation but decreases its explanatory power marginally by 0.65% for the \(\Delta p_t\) equation.

Secondly, I use the contemporary growth data of re-exports to all destinations and inflation data from WPI in the exogenous section in Specification (c). Surprisingly, I find that the explanatory power of the model has been significantly improved when compared with the baseline model: more than 16% of the output growth variance and about 1.4% of the inflation variance can be explained by adding the two exogenous variables in Specification (c). It is worthwhile to point out that Specification (c) has simultaneously improved the adjusted \(R^2\) for both equations. This has profound policy implications. The re-exports activities to all destinations are essential for Hong Kong’s economy. These activities represent Hong Kong’s close economic relationship with Mainland China, as I have shown in the two-way entrepot trade pattern related to Mainland China in the preliminary analysis.

Moreover, I wish to investigate why Specification (c) has significantly improved its explanatory power when compared to (b), although the correlation coefficient between the two re-exports data is fairly high (0.797). I notice that the growth of re-exports to Mainland China was more volatile from 1984 to 1986 in Figure 3-14 when compared with the growth of re-exports to all destinations. When I examine the proportion of the two re-exports data, I also find that the proportion in 1985 is an outlier, which is much higher than the other observations nearby. If I take out 1985, I find that the proportion of re-exports to China has been gradually increasing over the past two decades: in the earlier years, the proportion is approximately 30%; while in 2007 the proportion is approximately 50%.
Figure 3-16

NOTE:
This figure is included on page 80 of the print copy of the thesis held in the University of Adelaide Library.

Source of data: Hong Kong C&S Department.

- Meanwhile, I re-estimate Model II in specification (b) using a smaller sample (1987Q1 to 2007Q4) by taking out the early volatile observations. I achieved more consistent and satisfactory results, which are in (b)*. I discover that the adjusted $R^2$ for the output growth equation is 24.69%, which is very close to that of specification (c). I also pay attention to that the adjusted $R^2$ for the inflation equation is 9.14%, which is noticeably higher than 6.28% in specification (c). Compared with the baseline model without considering exogenous demand and supply factors (Specification (a)), Model II in specification (b)* provides an additional 15% and 4% explanatory power to Hong Kong’s output growth and inflation equations. These evidences suggest that entrepot trade activities do have significant impacts on Hong Kong’s economy.

- Finally, I also apply the first lag of growth data of re-exports to all destinations and inflation data from the WPI in the exogenous section in Specification (d). I find that these lag variables have reduced the explanatory power when compared with Specification (c). It indicates that the impacts of exogenous demand and supply on Hong Kong’s economy are contemporary (within a quarter).

3.6 Comparing the two models and further SVAR analysis

I use Specification #6 as a representative for Model I and Specification (c) as representative for Model II. I find that Model II can provide noticeably better explanatory power for Hong Kong’s output growth and inflation. This suggests that the Chinese economy has a considerable closer link to Hong Kong than the US economy. This finding is opposite to one reference’s findings that the US impact on Hong Kong’s economy is
considerably bigger than its Chinese counterparts. In conclusion, the external demand and supply from Mainland China are the key factors which play a significant role on Hong Kong’s economy.

Table 3-7 Model selection III

<table>
<thead>
<tr>
<th>Model specifications</th>
<th>Adjusted $R^2$ for the $\Delta y_t$ equation</th>
<th>Adjusted $R^2$ for the $\Delta p_t$ equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_t = CC + D_1 X_{t-1} + D_2 X_{t-2} + AA Z_t + U_t$</td>
<td>0.165442</td>
<td>0.038965</td>
</tr>
<tr>
<td>$X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta \text{fimp}_t \ \Delta \text{fp}<em>t \ f_t - f</em>{t-1} \ \Delta \text{freer}_t \end{bmatrix}$</td>
<td>0.257205</td>
<td>0.062872</td>
</tr>
<tr>
<td>$X_t = \begin{bmatrix} \Delta y_t \ \Delta p_t \end{bmatrix}, Z_t = \begin{bmatrix} \Delta \text{reex2all} \ \Delta \text{wpi}_t \end{bmatrix}$</td>
<td>0.257205</td>
<td>0.062872</td>
</tr>
</tbody>
</table>

I will use Model II to conduct further SVAR analysis for Hong Kong. I recover structural VAR from unrestricted VAR following the same approach in Chapter Two: I estimated the parameters for an unrestricted VAR as follows:

$$X_t = CC + D_1 X_{t-1} + D_2 X_{t-2} + AA Z_t + U_t.$$ 

I get a constant vector $CC$, parameter matrix $D_1, D_2, AA$ and variance-covariance matrix $\text{var}(U_t)$. From $\text{var}(U_t)$ I can generate 3 equations. Moreover, in order to just-identify the structural model, I am supposed to provide one more equation by imposing the Blanchard and Quah long-run restrictions, which define the money neutrality in the long run. I identify my structural parameters in $B_0$ and $\text{Var}(E_t)$ in the Mathematica by solving four unknowns in four equations. Reference of the methodology from Hamilton (1995) is listed in the Appendix C.

Here are the parameters I recovered for the structural VAR model:

$$B_0 = \begin{bmatrix} 1 & 0.0407766 \\ 0.0305029 & 1 \end{bmatrix}, A_0 = B_0^{-1} = \begin{bmatrix} 1.00125 & -0.0408274 \\ -0.0305409 & 1.00125 \end{bmatrix},$$

$$\text{Var}(E_t) = \begin{bmatrix} 3.77854 & 0 \\ 0 & 1.16826 \end{bmatrix}.$$ 

I reiterate the importance of the methodology which I applied in indentifying my structural VAR model. The parameters in the variance matrix I identified are not unitary, although some literature (Kwan and Lui (1999)) has applied the unitary assumption to identify their
structural VAR parameters. My results have supported the findings reported in Ceccetti and Rich (2001) and Green (2003) and therefore my SVAR models are robust.

After the structural VAR model is identified, I convert it into a Vector Moving Average form (VMA). Subsequently I conduct impulse response function analysis and variance decomposition analysis to provide more insightful analysis. I wish to investigate whether these features have been changed significantly or not when using the re-export data and the WPI data to represent external demand and supply factors. Note that I use my crisis-adjusted model for the currency board regime from chapter two as the baseline model in this chapter.

I display and compare the impulse response functions (IRFs) for the two SVAR models. As I mentioned before, IRFs examine the output growth and inflation’s response to one standard deviation output growth and inflation shocks, representing aggregate demand and supply shocks respectively.

*Figure 3-17 Impulse response functions for SVAR of Model II*
When comparing the above two impulse response functions (IRFs) graphs, I discover that they look almost identical in terms of the response patterns and response magnitude to standardised shocks. The reason is that the IRFs only consider domestic shocks in a Structural VAR model. External shocks could not be analysed in the IRFs model, even although I have included exogenous supply and demand data in Model II. The basic structure of the domestic shocks still remains considerably stable in Model II.

I also find that these models share similar patterns in the variance decomposition in terms of their ratios. Variance decomposition provides a quantitative view of the source of variation of domestic output growth and inflation. For example, in the medium and long term, aggregate supply shocks can explain about 97% of the output growth variance in Hong Kong. Admittedly, this analysis can only consider the domestic factors. Although model II considers the exogenous re-exports and WPI data, their impact on IRFs and variance decomposition are not available in a SVAR structure. However, I can use SVAR model to analyse which exogenous variables have significant impacts on Hong Kong’s output growth and inflation, as I did by comparing the results of Model II and the baseline model.
### Table 3-8 Variance decomposition for the SVAR of model II

<table>
<thead>
<tr>
<th>Period</th>
<th>Aggregate supply shocks ($\epsilon_i^y$)</th>
<th>Aggregate demand shocks ($\epsilon_i^p$)</th>
<th>Period</th>
<th>Aggregate supply shocks ($\epsilon_i^y$)</th>
<th>Aggregate demand shocks ($\epsilon_i^p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99.949</td>
<td>0.0510201</td>
<td>1</td>
<td>1.72804</td>
<td>98.272</td>
</tr>
<tr>
<td>2</td>
<td>98.6732</td>
<td>1.32685</td>
<td>2</td>
<td>2.15709</td>
<td>97.8429</td>
</tr>
<tr>
<td>3</td>
<td>97.2634</td>
<td>2.73661</td>
<td>3</td>
<td>7.8055</td>
<td>92.1945</td>
</tr>
<tr>
<td>4</td>
<td>97.2377</td>
<td>2.76234</td>
<td>4</td>
<td>7.7932</td>
<td>92.2068</td>
</tr>
<tr>
<td>5</td>
<td>97.2789</td>
<td>2.72114</td>
<td>5</td>
<td>8.02504</td>
<td>91.975</td>
</tr>
<tr>
<td>8</td>
<td>97.2203</td>
<td>2.7797</td>
<td>8</td>
<td>8.15079</td>
<td>91.8492</td>
</tr>
<tr>
<td>12</td>
<td>97.2193</td>
<td>2.78066</td>
<td>12</td>
<td>8.16731</td>
<td>91.8327</td>
</tr>
<tr>
<td>16</td>
<td>97.2193</td>
<td>2.7807</td>
<td>16</td>
<td>8.16788</td>
<td>91.8321</td>
</tr>
<tr>
<td>20</td>
<td>97.2193</td>
<td>2.7807</td>
<td>20</td>
<td>8.16789</td>
<td>91.8321</td>
</tr>
</tbody>
</table>

### Table 3-9 Variance decomposition for the SVAR of the baseline model

<table>
<thead>
<tr>
<th>Period</th>
<th>Aggregate supply shocks ($\epsilon_i^y$)</th>
<th>Aggregate demand shocks ($\epsilon_i^p$)</th>
<th>Period</th>
<th>Aggregate supply shocks ($\epsilon_i^y$)</th>
<th>Aggregate demand shocks ($\epsilon_i^p$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99.703</td>
<td>0.296979</td>
<td>1</td>
<td>3.50606</td>
<td>96.4939</td>
</tr>
<tr>
<td>2</td>
<td>98.5393</td>
<td>1.46072</td>
<td>2</td>
<td>3.78574</td>
<td>96.2143</td>
</tr>
<tr>
<td>3</td>
<td>96.4826</td>
<td>3.51744</td>
<td>3</td>
<td>7.62026</td>
<td>92.3797</td>
</tr>
<tr>
<td>4</td>
<td>96.4647</td>
<td>3.53526</td>
<td>4</td>
<td>7.64336</td>
<td>92.3566</td>
</tr>
<tr>
<td>5</td>
<td>96.4855</td>
<td>3.51446</td>
<td>5</td>
<td>7.71581</td>
<td>92.2842</td>
</tr>
<tr>
<td>8</td>
<td>96.4404</td>
<td>3.55963</td>
<td>8</td>
<td>7.76236</td>
<td>92.2376</td>
</tr>
<tr>
<td>12</td>
<td>96.4398</td>
<td>3.56018</td>
<td>12</td>
<td>7.76433</td>
<td>92.2357</td>
</tr>
<tr>
<td>16</td>
<td>96.4398</td>
<td>3.5602</td>
<td>16</td>
<td>7.76435</td>
<td>92.2356</td>
</tr>
<tr>
<td>20</td>
<td>96.4398</td>
<td>3.5602</td>
<td>20</td>
<td>7.76435</td>
<td>92.2356</td>
</tr>
</tbody>
</table>

The sacrifice ratio analyses the impacts of one standard inflation shock (supply shock) both on output growth and inflation, by comparing the cumulative output change and inflation gained. Admittedly under the currency board regime, such a ratio does not represent the HKMA’s inflation control policy mission. As I mentioned in the previous chapter, HKMA’s priority is to defend the fixed exchange rate with the US dollar. HK’s
interest rate has to move close to the US counterpart and the interest rate movement does
not necessarily represent HKMA’s inflation control policy. I will examine the difference of
the sacrifice ratios between the two models. Evidence from table 3-10 and 3-11 suggests
that the ratios are stable across the time periods and similar in terms of magnitude.

Table 3-10 Sacrifice ratio analysis

<table>
<thead>
<tr>
<th>SVAR Models</th>
<th>Quarters</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model II</td>
<td></td>
<td>-0.2192</td>
<td>-0.2212</td>
<td>-0.2212</td>
<td>-0.221</td>
<td>-0.221</td>
</tr>
<tr>
<td>Baseline model</td>
<td></td>
<td>-0.3907</td>
<td>-0.3821</td>
<td>-0.3796</td>
<td>-0.3789</td>
<td>-0.3785</td>
</tr>
</tbody>
</table>

Source: author’s estimation.

Table 3-11 The mean and 90% confidence intervals of the sacrifice ratios

<table>
<thead>
<tr>
<th>Quarters</th>
<th>Median</th>
<th>90% confidence intervals (bootstrap methods)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>-0.2627</td>
<td>-1.3729 0.7696</td>
</tr>
<tr>
<td>8</td>
<td>-0.3779</td>
<td>-2.685 1.8857</td>
</tr>
<tr>
<td>12</td>
<td>-0.462</td>
<td>-4.1295 3.1165</td>
</tr>
<tr>
<td>16</td>
<td>-0.5768</td>
<td>-5.5473 4.3681</td>
</tr>
<tr>
<td>20</td>
<td>-0.6848</td>
<td>-6.9404 5.6215</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The baseline model</th>
<th>Median</th>
<th>90% confidence intervals (bootstrap methods)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>-0.4227</td>
<td>-1.7177 0.7969</td>
</tr>
<tr>
<td>8</td>
<td>-0.4386</td>
<td>-3.3512 2.3372</td>
</tr>
<tr>
<td>12</td>
<td>-0.4345</td>
<td>-5.1573 4.0648</td>
</tr>
<tr>
<td>16</td>
<td>-0.4368</td>
<td>-6.9766 5.8156</td>
</tr>
<tr>
<td>20</td>
<td>-0.4873</td>
<td>-8.7962 7.5348</td>
</tr>
</tbody>
</table>

Source: author’s estimation.

In general, compared with the baseline model, Model II has maintained its stable
SVAR features in terms of impulse response function, variance decomposition and
sacrifice ratios even when I consider the exogenous demand and supply effect captured by
the re-exports data and the WPI data.

3.7 Major findings and conclusions

In this chapter, I have conducted further study on Hong Kong’s economy under the
Currency Board period (1984-2007) in consideration of the exogenous impact of the
Chinese and US economies.
What are the major exogenous variables which deliver the impact of the US economy on Hong Kong?

I have answered this research question in Model I and investigated the major channels in which Hong Kong’s economy under the currency board regime is affected by the US economy. First, I have investigated the interest rate level of Hong Kong and find that it moves closely to its US counterpart across time except for some short-run deviation during the Asian finance crisis. The US interest rate plays a significant role in Hong Kong’s economy because of the fixed exchange rate arrangement. Secondly, I have analysed the real and nominal effective exchange rates between Hong Kong and the United States, and find that both Hong Kong’s changes in REER and NEER are highly correlated with their US counterpart. The correlation coefficients are 0.713 and 0.920 respectively. Therefore change in REER from the US is also a favourable exogenous variable which might have significant impact on Hong Kong’s economy. Furthermore, I have applied the US import and inflation data to capture the external aggregate demand and supply movement in Hong Kong.

Instead of following Genberg, Liu and Jin (2006)’s approach to put all the Hong Kong and US data in the endogenous section to form a big SVAR system, I use my chapter two empirical model of Hong Kong’s output growth and inflation as a baseline model and subsequently consider more US data in the exogenous variable section in that model. This approach is more consistent with the real economy situation in Hong Kong. Moreover, it is capable to indentify those variables which deliver significant impacts on Hong Kong. First I have considered the US imports and inflation data to the baseline UVAR model, and discovered that the explanatory power for the output equation has been significantly improved (4.3% increase), while the explanatory power for the inflation equation has been marginally reduced (0.6% decrease). Also I have tested the lag variables of US output growth and inflation in the model and found that they can not improve the model; therefore, only contemporary US variables will be considered. The intuitive explanation is that the US economy can deliver its full impact to Hong Kong within the same quarter (3 months).

Furthermore, I have examined the impacts of the US interest rate movement and the impact of the change of REER on Hong Kong. I find that both of them have improved the explanatory power of the output growth equation. These findings are consistent with the fact that under a fixed exchange rate regime, there is a considerable correlation between the US and the Hong Kong interest rate. Moreover, the change in REER from Hong Kong
is also highly correlated to its US counterpart. It is worthwhile to point out that adding more exogenous US explanatory variables to my study has failed to improve the explanatory power for Hong Kong’s inflation equation. My evidence suggests that the US economy has little impact on the inflation of Hong Kong.

What are the key exogenous variables which can capture the close economic relationship between Mainland China and Hong Kong SAR?

As a small open economy, Hong Kong flourishes in international trade and trade-related services such as finance, logistics and transportation. The most striking feature is that Hong Kong plays a very important role in the entrepot trade for Mainland China. Therefore, entrepot trade data can provide a good proxy of the close economic partnership with Mainland China. I examine Hong Kong entrepot trade patterns in detail and illustrate that the re-export activities in Hong Kong follow two-way directions. On one hand, Hong Kong helps China to export its products to the rest of the world; on the other hand, Hong Kong also assists China to import goods from the rest of the world.

In model II I have used a similar approach. First I have considered contemporary growth data of re-exports to Mainland China and inflation data from WPI to the exogenous section in the model. I discover that this specification can only increase its explanatory power (approximately 1.8%) for Hong Kong’s output equation but decreases its explanatory power marginally (0.65) for the inflation equation.

Second, I have included the contemporary growth data of re-exports to all destinations and inflation data from WPI in the exogenous section of my empirical model. Interestingly I discover that the explanatory power of such a model has been significantly improved compared with the baseline model: more than 16% of the output growth variance and approximately 1.4% of the inflation variance can be explained by adding those two exogenous variables. It is worthwhile to point out that the specification has simultaneously improved the adjusted-$R^2$ for both equations. The above evidence suggests that the re-export activities are essential for Hong Kong’s economy, and they represent Hong Kong’s close economic relationship with Mainland China.

I have investigated the reason why the data to all destinations has significantly improved its explanatory power compared with the data from Mainland China, although the correlation coefficient between the two re-exports data is considerably high (0.797). Evidences suggest that the quarterly growth data in 1985 are very volatile and the 1985
yearly data of re-exports to Mainland China can be characterised as an outlier. Therefore, I re-estimate Model II in specification (b) using a smaller sample and received more consistent and satisfactory adjusted $R^2$ results. Compared with the baseline model without considering exogenous demand and supply factors, Model II using growth of the re-exports to China (1987-2007) provides an additional 15% and 4% explanatory power to Hong Kong’s output growth and inflation equations. This evidence suggests that entrepot trade activities related to Mainland China do have a significant impact on Hong Kong’s economy.

Moreover, I have applied the first lag of growth data of re-exports to all destinations and inflation data from WPI in the exogenous section. Evidence suggests that these lag variables have reduced the explanatory power. It reveals that the impacts of exogenous demand and supply on Hong Kong’s economy are contemporary (within a quarter).

*Which of my two macroeconomic models can best capture the impact of external demand and supply on Hong Kong’s economy?*

I have compared Model I and Model II, which capture the impacts of the US and the Chinese external aggregate demand and supply factors on Hong Kong’s economy. Evidence suggests that Model II provides a significantly better explanatory power for Hong Kong’s output growth and inflation. Model II reveals the importance of the Chinese economy which has a much closer link to Hong Kong than the US economy. My finding contradicts to some literature which concludes that the Chinese economy is much less significant than the US economy in explaining Hong Kong’s output variance.

Furthermore, I have applied the parameters of UVAR of Model II to recover the parameters of the SVAR. I have investigated whether the basic features of Hong Kong’s output growth and inflation have changed significantly when I consider re-exports and WPI data as the exogenous factors in the empirical model. I have analysed the impulse response functions, variance decomposition and sacrifice ratios of Model II, and compared them with those in the baseline model, which did not consider external demand and supply factors. Evidence suggests that that these features are very similar to those of the base-line model and no significant changes have been found. The basic conclusion is that the relationship of Hong Kong’s output growth and inflation remain stable, even when I consider the external demand and supply factors in the empirical model.
Chapter 4
A re-examination of Hong Kong’s and Singapore’s different exchange rate regimes in real exchange rate misalignment----considering the impact of entrepot trade

4.1 Introduction
Hong Kong and Singapore are two small open economies in Asia. Both economies have experienced rapid economic growth in the past forty years and have gradually developed into major finance and international trade and service centres in Asia during the industrialisation process. Moreover, many of their economic activities are entrepot trade related. The figures in table 4-1 illustrate the significance of re-export activities in both economies, particular in Hong Kong, where over 95% of its exports are actually re-exports of merchandised goods from Mainland China to the rest of the world. Therefore, it is important to consider the impact of re-exports when studying the real effective exchange rates in Hong Kong and Singapore.

Table 4-1 Trade figures in 2007

<table>
<thead>
<tr>
<th></th>
<th>Singapore</th>
<th>Hong Kong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exports</td>
<td>450,627.7 million SG dollars</td>
<td>2,687,513 million HK dollars</td>
</tr>
<tr>
<td>Re-exports</td>
<td>224,172.5 million SG dollars</td>
<td>2,578,392 million HK dollars</td>
</tr>
<tr>
<td>Re-exports ratio</td>
<td>49.75%</td>
<td>95.94%</td>
</tr>
</tbody>
</table>

Source of data: International Enterprise Singapore and Censors & Statistics Department of Hong Kong. The re-exports ratios are calculated by the author.

In the late 1990s, the Asian financial crisis brought recession to both economies, but their recovery experiences were very different. As I have shown in Figure 1-1, evidence reveals that Singapore recovered from the crisis faster than Hong Kong by a couple of quarters. Moreover, the latter suffered from a five-year-long deflation until the beginning of 2004, when the economy was fully recovered from the recession. Besides sharing some common features as small open economies, Hong Kong and Singapore also have their own unique characters, which might play an essential role in the individual economy. The most distinctive difference lies in the choice of different exchange rate regimes. Is there any
evidence to support that the flexible exchange rate regime performs better than the fixed exchange rate regime in terms of real effective exchange rate misalignment?

The Hong Kong Monetary Authority (HKMA) adopted a Currency Board Arrangement (CBA) in the third quarter of 1983 in order to strengthen the confidence of the general public and international investors in the local economy. Ever since then, Hong Kong’s nominal exchange change rate has been fixed to the US dollar. The Hong Kong government and most of the citizens believe that such an arrangement has created a stable environment to develop the economy.

The Monetary Authority of Singapore (MAS) has implemented a managed floating regime since June 1973. The authority takes care of the nominal exchange rate against an undisclosed basket of major trading partner currencies in a relatively flexible manner. Since Singapore’s currency in circulation is still backed by the foreign assets of its major trading partners, some people interpret this as ‘pegging’ the Singapore dollar to a basket of foreign currencies. Under such an exchange rate arrangement, Singapore’s nominal exchange rate in terms of the US dollar is flexible. On the other hand, MAS can monitor the movement of the nominal exchange rate within a ‘monitoring band’ and attempt to smooth out real exchange rate fluctuations. Although MAS does not attempt to make it clear how it operates its exchange rate regime, many believe that MAS is actually targeting a Real Effective Exchange Rate (REER), which represents an overall competitiveness against its major trading partners. By doing so, MAS attempts to ensure that its REER is consistent with the economic fundamentals and creates an optimum exchange rate path, which can stabilize the domestic price level and also maintain sustainable economic growth.

The aim of this chapter is to examine the real effective exchange rate misalignment of the two economies, and provide clear evidence on the performance of the two different exchange rate regimes. Hong Kong’s and Singapore’s international trade has one unique character in that entrepot trade plays a significant role in their import and export activities. The literature has paid little attention to such a very important character and evidence suggests a larger scale REER misalignment in Hong Kong compared with Singapore. By comparison, this study has considered the re-exports and offered strikingly different conclusions. The new evidence suggests that Hong Kong performs equally well in terms of real exchange rate misalignment under a fixed exchange rate regime.
In this chapter, I attempt to carry out my empirical studies to address the following questions for Hong Kong and Singapore:

- **What are the major economic fundamental variables for these two small open economies, which can explain the equilibrium behaviour path of the REER?**
  Particularly, have the entrepot trade variables played an important role in the empirical models of REER for Hong Kong and Singapore?

- **What is the overall performance of the two exchange regimes? Which regime can create a stable macro environment in terms of a lower degree of REER misalignment and faster return to equilibrium? Did the currency board regime bring large-scale real exchange rate misalignments to Hong Kong?**

In this chapter, I will first examine major approaches for assessing the extent to which a real effective exchange rate (REER) is consistent with economic fundamentals: the Fundamental Equilibrium Exchange Rate (FEER), Natural Real Exchange Rate (NATREX) and the Behaviour Equilibrium Exchange Rate (BEER). Second, I will discuss the determinants of the real exchange rate by examining theoretical models and empirical studies. I point out the limitations of the existing literature which only follows the standard model specifications for big economies such as United States, while failing to identify the key explanatory variables which capture the unique features for the economies of Hong Kong and Singapore. Consequently, in some literature, for the case of Hong Kong, some significant exchange rate misalignment has been found but no reasonable explanation is provided. Therefore, it is still unclear whether there is huge real exchange rate misalignment associated with a currency board regime in Hong Kong. In this chapter, I re-examine all the major fundamental variables and select those essential for Hong Kong and Singapore, such as openness and re-exports. My empirical evidence shows that Hong Kong’s currency board system functions equally well in terms of real exchange rate misalignment, compared with Singapore which implements a managed floating exchange rate regime.

### 4.2 Major approaches to model real exchange rates

Three major approaches (FEER, NATREX and BEER) to model real exchange rates will be examined and compared in this section.

#### 4.2.1 The FEER approach

According to Williamson (1994), the Fundamental Equilibrium Exchange Rate (FEER) concept is based upon the macroeconomic balance in terms of internal and external
dimension. Internal balance is defined as the level of output consistent with both full employment (i.e. unemployment rate equals NAIRU) and a low and sustainable rate of inflation. External balance is characterized as the sustainable desired net flow of resources between countries when they are in internal balance. The FEER approach is a normative measure to calculate a real exchange rate. Williamson points out that FEER is an equilibrium exchange rate, which is consistent with some ideal economic conditions. In other words, this approach calibrates the real exchange rate at a set of well-defined economic conditions, which have to be decided by the author in a sensible way. For external balance, the current account (CA) must be equal to the negative of capital account (KA), i.e. $CA = -KA$. The current account is determined by a function of home and foreign output $y_d$ and $y_f$ respectively, and the real effective exchange rate $q$. The equilibrium current account model is defined as follows:

$$\overline{CA} = b_0 + b_1 q + b_2 \overline{y_d} + b_3 \overline{y_f},$$

where $b_1 < 0, b_2 < 0, b_3 > 0$. Since $\overline{CA} = -\overline{KA}$, one can solve for the real effective exchange rate $q$, i.e. $FEER = (\overline{KA} - b_0 - b_2 \overline{y_d} - b_3 \overline{y_f}) / b_1$. A FEER calculation requires considerable parameter estimation and judgement involving: (1) a current account model, (2) estimates of potential output for the country concerned and its main trading partners, (3) an estimate or judgement regarding capital account $\overline{KA}$. Faruqee, Isard, and Masson (1996) further develop the approach by indentifying the equilibrium current account as the difference between desired aggregate saving and investment at full employment, i.e. $\overline{CA} = \overline{S} - \overline{I}$ and $-\overline{KA} = \overline{CA} = \overline{S} - \overline{I}$.

### 4.2.2 The NATREX approach

According to Allen (1997), the NATREX (or NATural Real EXchange rate) is the equilibrium real exchange rate that clears the balance of payments in the absence of cyclical factors, speculative capital flows, and movements in international reserves. A NATREX model starts at some hypothetical inter-cyclical medium run, in which prices have adjusted and output has returned to its inter-cyclical potential level. The real exchange rate has adjusted to its current equilibrium level. Demand for money equals to prevailing supply of money, with no foreign-exchange intervention by the central banks. This medium-run equilibrium, constituting the ‘long-run equilibrium’ of most monetary models, is the starting point of a NATREX model.
The medium-run market-clearing equilibrium of a NATREX model can be described by the familiar national-income-accounts equation, i.e. \( I - S + CA = 0 \), where \( I \) is the desired national investment, \( S \) is the desired national saving, and \( CA \) is the desired current account, all measured when the economy is at capacity output and expectations about inflation are met. The real exchange rate \( R \) appreciates in response to an excess demand for goods, insuring that equilibrium is maintained. This equation can be interpreted as the equilibrium condition for the balance of payments, as well as for the goods market. The NATREX models assume that real exchange rate only affects current account but does not influence \( I - S \). Meanwhile, desired investment and saving depend on the existing stocks of capital \( k \), wealth \( w \) and net debt to foreigners \( F \). Changes in stocks of capital, wealth and net foreign debt will alter desired \( I, S \) and \( CA \), calling for new equilibrium real exchange rates.

Exogenous fundamental disturbances \( Z \) — such as changes in thrift and productivity, at home and abroad, and for small countries, changes in the terms of trade and the world real interest rate — influence the NATREX in two ways. They first affect desired investment, saving, or the current account, inducing a change in the NATREX in the medium run. Second, by changing the rates of accumulation of capital, wealth and net foreign debt, the exogenous fundamentals alter the trajectory of the NATREX as it moves toward its new long-run equilibrium. At any point other than long-run equilibrium, the NATREX is a function of both exogenous (\( Z \)) and endogenous fundamentals (such as capital, wealth and net foreign debt).

Empirical models applying the NATREX approach studying real exchange rates can be found in Stein (1995), Lim & Stein (1995), Crouchy-Veyrac & Marc (1995) Connolly & Devereux (1995). In Stein’s paper, net capital flows are determined by the difference between investment and saving. The determinants of investment and saving are the time preference rate and Tobin’s \( q \) ratio respectively. On the current account side, productivity and thrift (willingness to save and economies in spending) are the key determinants, which influence the real exchange rate through changes in the current account. In the NATREX model, the steady state can be regarded as a path in which the real exchange rate, the capital stock and the net foreign assets are at their long term values.

The NATREX is a positive, not a normative, concept of the equilibrium real exchange rate. It is the rate implied by the real fundamentals and by the existing economic policies. In this respect, the NATREX approach differs from Williamson’s FEER approach, which is looking for a measure of the real exchange rate that will serve as a guide for
policy. The FEER is the real exchange rate that will bring the current account, measured at potential output, into line with some measure of ‘desirable capital flows’. The desirable capital flows equals the difference between levels of investment and saving that are not distorted by public policy. This normative element is the major difference between the definitions of the NATREX and FEER approaches.

4.2.3 The BEER approach
Faruqee (1995) initiates the Behavioural Equilibrium Exchange Rate (BEER) approach from the balance-of-payments equation which equates the current account with the capital account. The current account balance is the sum of the trade balance, which is a function of the real exchange rate $q$ and exogenous variables ($X$), and interest income received (or paid) on a country’s net foreign asset (or debt) position $F = CA = c.q + X + r.F$, where $c < 0$ and $r$ is the domestic real interest rate. Faruqee points out that a viable balance of payments position required that the current account be financed by a desired level of capital flows in capital account $KA$. The desired level of capital flow is a function of the real interest rate difference (between home country and rest of the world) and foreign assets gap (the desired level minus the actual level): $KA = d.(r - r^*) + f.(F^d - F)$, where $d < 0, f > 0$. The balance of payments equation required that $CA = KA$, and the function of real exchange rate $q$, is set up via such an equation: $q = \bar{q} + s.(F - \bar{F})$, where $\bar{q}$ and $\bar{F}$ are the equilibrium levels of real exchange rate and net foreign asset and $s > 0$. The solution for $\bar{q}$ is given by $\bar{q} = (r/c)\bar{F} + (1/c)\bar{X}$. In Faruqee’s empirical model, the author chooses productivity growth differentials, the relative price of non-tradables, and terms of trade as ($X$) variables determining the current account. Furthermore the author also defines the actual stock of net foreign assets as an exogenous variable. The author attempts to explain the real effective exchange rate of Japanese yen and US dollar in terms of the above economic fundamentals. The fitted value of the real exchange rate from the cointegration equation represents trend values, which are consistent with the specified economic fundamentals.

Clark & MacDonald (1998) also follow the BEER approach in modelling the long-run exchange rate. They start the theoretical model with a risk-adjusted interest parity condition: $E_i[\Delta s_{t+k}] = -(i_t - i_t^*) + \pi_t$, where $s_t$ is the foreign currency price of a unit of home currency, $i_t$ denotes a nominal interest rate, $\pi_t$ is the risk premium that has a time-
varying component $\lambda_i$ (i.e. $\pi_i = c + \lambda_i$), $\Delta$ is the first difference operator, $E_i$ is the conditional expectations operator, and $t+k$ defines the maturity horizon of the bonds. This condition may be converted into a real relationship by subtracting the expected inflation differential, $E_i(\Delta p_{t+k} - \Delta p^*_{t+k})$ from the nominal exchange rate and interest differential.

After rearrangement, the condition becomes: $q_i = E_i[q_{t+k}] + (r_i - r^*_i) - \pi_i$, where $r_i = i - E_i(\Delta p_{t+k})$ is the ex ante real interest rate. In this equation, the current equilibrium exchange rate is determined by three components: the expectation of the real exchange rate in period $t+k$, the real interest differential with a maturity $t+k$, and the risk premium. The authors assume that the time-varying component $\lambda_i$ of the risk premium term $\pi_i$ is a function of the relative supply of domestic to foreign government debt: $\lambda_i = g(gdebt_i - gdebt^*_i)$. The authors also assume that the unobservable expectation of the exchange $E_i[q_{t+k}]$ is determined solely by the long-run economic fundamentals $Z_i$. They denote the long-run equilibrium exchange rate as $\bar{q} = E_i[q_{t+k}] = E_i[\beta_i Z_{t+i}] = \beta_i Z_{t+i}$. The long-run economic fundamental vector $Z_i$ includes three major variables: term of trade $tot_i$, the relative price of non-traded to traded goods $ntn_i$ and net foreign asset $nfa_i$. All these three variables are supposed to have a positive association with the long-run equilibrium exchange rate. Clark and Macdonald’s BEER model has five endogenous and exogenous fundamental variables: $BEER = f(r - r^*, gdebt / gdebt^*, tot_i, ntn_i, nfa_i)$.

The BEER approach attempts to explain the behavioural equilibrium exchange rate in terms of a set of fundamental economic variables. This approach applies real exchange rate and some fundamental economic variables to a Vector Error Correction Model (VECM) system and tests whether a long-term cointegration relationship exists among these variables. If a linear combination among the variables of interest is stationary, one can conclude that a cointegration relationship exists between real exchange rate and its determinants. Such a relationship represents a long-run ‘equilibrium path’ in which the desired real change exchange rate can be estimated given those fundamental variables. It should be clarified that the cointegration relationship itself does not necessarily guarantee that internal and external balances exist. Details of VECM models are explained in Appendix E.

Similar examples of the BEER approach can also be found in empirical studies such as MacDonald (1995), Kramer (1996), Goldman Sachs (1996, 1997), Clark & MacDonald (1998) etc. Also a vast literature on REER misalignment in different economies could be
found in IMF working papers, such as Cerra & Saxena (2000), Mathisen (2003), MacDonald & Ricci (2008), Abdih & Tsangarides (2008). Detailed literature review of these papers follows in section 4.3.

There are a few essential features of the BEER approach which can distinguish it from the FEER approach. First of all, the BEER attempts to explain the behavioural equilibrium exchange rate in a set of actual economic data (trend data), instead of a set of ideal economic variables. Second, the real exchange rate in BEER approach has a long-run component and a short-run component. On the other hand, the FEER approach does not contain short-run components.

4.2.4 A comparison of the BEER and the NATREX approaches
Both the BEER and the NATREX approaches utilize the balance-of-payment equation as a foundation in theoretical modelling. In empirical studies, both approaches examine the cointegration relation between the real effective exchange rate and a set of economic foundational variables and generate a path for the desired or equilibrium real exchange rate.

However, the real exchange rate from the NATREX approach is the equilibrium rate that brings equilibrium conditions for the balance-of-payment and goods market for a given macroeconomic condition (stocks of capital, wealth and net foreign debt), while the real exchange rate from the BEER model is the desired exchange rate which is consistent with the economic fundamentals. A real exchange rate from a BEER model does not necessarily guarantee equilibrium conditions for the balance-of-payment and goods market.

The BEER approach is popular in most recent empirical studies on real exchange rates, given the flexibility of the approach in model specification. The NATREX approach has limited freedom in model specification given that the approach aims to identify the equilibrium exchange rate which brings equilibrium conditions for the balance-of-payment and goods market. In this regard, the selection of endogenous and exogenous variables must be consistent with the theoretical model adopted. By contrast, the BEER approach aims to identifying the behavioural equilibrium exchange rate which is consistent with the current situation of the economy. Therefore, one can choose major fundamental variables which have significant impact on the economy in the empirical study. For instance, MacDonald & Ricci (2008) select real commodity prices as one of the major explanatory variables in studying the real exchange rate in South Africa.
4.3 Literature review on empirical studies on REER misalignment

There are a vast number of empirical studies modelling real effective exchange rates and identifying the REER misalignment. Leading research on the field can be found on some IMF working papers: Clark & MacDonald (1998), MacDonald & Ricci (2008), Abdih & Tsangarides (2008). These papers followed the BEER approach and applied Johanson’s cointegration methods to estimate the desired real effective exchange rate (BEER) and evaluate the misalignment gap between the BEERs and the actual REERs in a variety of economies, such as the US, Japan, Germany, South Africa, and Central and West African countries. All these papers indicate the popularity of the methodology in modelling the real effective exchange rate. Furthermore, Candelon et al. (2006) followed the BEER approach and estimated bilateral equilibrium real exchange rates for a group of eight new EU member states against the euro, using new panel-cointegration techniques.

There are a few papers in the literature studying the real exchange rate in Hong Kong and Singapore: Zhang (2000), Siregar & Walker (2000), Rajan & Siregar (2002), Leung & Ng (2007). All these papers carried out the empirical modelling via cointegration equations, which capture relationships between the real effective exchange rate and its key explanatory fundamental variables. Siregar & Walker (2000) and Rajan & Siregar (2002) both followed the NATREX approach to conduct their empirical studies, while Leung & Ng (2002) applied different approaches (including FEER) to analyse the exchange misalignment.

All the existing literature applies common explanatory variables which are significant in large countries but may not be in Hong Kong. For example, Zhang (2000) analyses the impact of a resource gap on Hong Kong, which does not play a significant role in Hong Kong’s economy. Moreover, the author makes a strong assumption that private investment ratio is a good proxy for the non-tradable sector investment. However, there is no solid evidence or reliable source of information indicating that the major part of the private sector investment has been made in the non-tradable sector. Zhang did make some contribution to the literature by considering the impact of terms of trade and openness on REER in Hong Kong. However, Zhang’s model is not robust as it considered a couple of insignificant variables while ignoring a couple of essential ones. Consequently, the policy implications from Zhang’s model are limited.

Siregar & Walker (2000) and Rajan & Siregar (2002) also consider some generally relevant variables, while ignoring some specific variables which are vital to Hong Kong’s economy. The former only models Hong Kong’s real exchange rate, while the later models
both Hong Kong’s and Singapore’s real exchange rates and compares the misalignments of real exchange rate in the two economies. Both papers model the real exchange rate with the same explanatory fundamentals: terms of trade, productivity, government expenditure, and the world interest rate.

Rajan and Siregar’s essential contribution is to compare the misalignment of real exchange rate in the two economies, which share a variety of similar characteristics. However, they only investigate some general variables, such as world interest rate, which may have limited impact on the models. Moreover, the effect of re-exports on REER has been ignored. I have demonstrated the importance of the re-export data which may play an essential role in determining real exchange rate. Most importantly, their real exchange rate model for Hong Kong indicates huge fluctuations over the period 1984 to 1987, but the real data show little evidence of large scale fluctuation.

Leung & Ng (2002) also analyse the misalignment of REER in different methods and offer comparisons. However, in their BEER models, they also only consider the impact of total trade on REER, without looking inside the composition of the trade activities. As I pointed out in section 4.1, among Hong Kong’s total trade figures in exports, 95% are related to the re-exports activities. Ignoring such an important variable might be critical to the empirical model. Moreover, literature such as Hanson & Feenstra (2001) analyses the entrepot trade patterns in Hong Kong. However, they only focus on analysing the re-exports patterns, but fail to analyse the impact of the re-exports activities on Hong Kong’s REER. Therefore, it is essential to conduct a careful re-examination of Hong Kong and Singapore’s REER models, particularly considering the impact of entrepot trade.

### 4.4 Empirical modelling

#### 4.4.1 Determinants of real exchange rate

This section will follow the BEER approach to carry out on empirical study given that Hong Kong and Singapore are two unique small open economies, and the BEER approach offers the freedom to choose major fundamental variables which have the most significant impact on the internal and external balance of the economies.

Following Abdih & Tsangarides (2008) and Candelon et al (2006), I summarize the expected signs for the major fundamental variables as follows:

- Terms of trade of goods. An increase of terms of trade has a positive association with the REER through the wealth effect. A positive terms-of-trade-shock will induce an increase in domestic demand, and hence an increase in the relative price
of non-tradable goods, which leads to a REER appreciation. Also, an increase in the terms of trade leads to an increase of real wages of the exports sector and a trade surplus. The REER must appreciate for the external balance to be restored. Therefore, the expected sign for terms of trade is positive.

- Openness. Openness captures the degree of trade restriction and the dependence of the macro economy on the foreign trade sector. For an economy with trade restriction, the subsequent increase in openness, representing for example a cut in tariff and non-tariff protection, will trigger an increased domestic demand for foreign tradable goods and a larger current account deficit. To maintain a sustainable current account, real exchange rate depreciation would be required. In this regard, rising openness implies real exchange rate depreciation. Alternatively, an increase in openness, representing more robust local exports and re-exports activities compared with the increase of imports, will result in stronger foreign demand for domestic or re-export products and a substantial current account surplus. Consequently, an increase in openness may imply an appreciation of real exchange rate. Empirically, the sign of the openness variable is ambiguous, given that it depends on how openness affects the import and export activities.

- Productivity. Productivity captures the Balassa-Samuelson (BS) effect. According the BS hypothesis, less developed economies typically experience a structural appreciation of their real exchange rate when they catch up with more developed economies. In the catching-up process, productivity in the domestic tradable goods sector will increase relative to that in the non-tradable goods sector. Under the assumptions that wage setting in the tradable goods sector dominates wage setting in the non-tradable good sector and that wages in the tradable and non-tradable sector will equalize due to domestic labour mobility, prices of domestic non-tradable goods increase relative to domestic prices of tradable goods. Consequently, an increase in productivity will cause a REER appreciation. The expected sign for productivity is positive.

- Real interest rate differential vis-à-vis major trading partners. An increase in the difference will imply an appreciation of real exchange rate in Clark and MacDonald's BEER model in Section 4.2.3, given the real interest rate parity equation. Moreover, an increase in the difference will imply influx of foreign direct investment which will results in improved productivity and appreciation of real
exchange rate. The expected sign for real interest rate differential is supposed to be positive. Empirical evidence can be found in MacDonald & Ricci (2008).

4.4.2 The importance of considering re-exports data

In chapter 3, evidence has shown that adding re-exports data in a structural VAR model on output growth and inflation has significantly improved the explanatory power of the SVAR model on Hong Kong’s output growth and inflation.

Figure 4-1 demonstrates the importance of considering re-exports data: in Singapore, almost 50% of its exports goods are re-exported merchandise. In Hong Kong, over 95% of its exports are actually re-exports of merchandised goods from Mainland China to the rest of the world.

One may argue that the re-export data are included in the openness data and these two series of data might be serially correlated. First of all, it is necessary to include the re-export data given that the openness data is calculated using import and export data and therefore will over-estimate Hong Kong’s foreign trade activities without the adjustment of the re-export data. Secondly, it is valid that major fundamental variables are correlated in a VECM model which examines the long-term cointegration relationship among these variables. For instance, Gonzalo & Granger (1995) attempt to identify the permanent component that is driving the interest rates of Canada and the US in the long run. The authors examine a VECM model which has six correlated variables: short-term interest rates, medium-term interest rates and long-term interest rates for the US and Canada.

4.4.3 Other explanatory variables selection

I consider the following selected variables. First, openness, which is common in relevant empirical studies, should be addressed by the empirical models for Hong Kong and Singapore. Openness can affect the real exchange rate by the increase of import and export of tradable goods. Although openness may have either a positive or negative impact on the real exchange rate, it is interesting to indentify how openness plays a role in determining the real exchange rate in these economies.

Second, it may be less significant to include the world interest rate in empirical studies although it can be found in some theoretical models. In theory, there are only two economies and capital inflow to the home country will happen if the local real interest rate is higher than the rest of the world, and vice versa. However, it is difficult to apply it in empirical research, given that there are many countries with different interest rates. Among
OECD countries there are high interest rates countries, such as Australia and low interest rates countries, such as Japan. Although the US interest rate is regarded as a representative of the world interest rate, it is difficult to draw a conclusion as to whether there will be significant capital inflow when the local interest rate is higher than the US interest rate. And it is also difficult to draw a conclusion about whether there will be significant capital outflow when the local interest rate is lower than the US interest rate. This is particularly significant when we study two small open economies characterized as major international finance centres. Moreover, Chapter 3 illustrates the close movement of nominal interest rates between Hong Kong and the US under the currency board regime. It is fair to assume that the real interest rate differential against major trading partners is not playing an essential role in affecting the real exchange rate. Similar model specification can be found on empirical studies applying the BEER approach, such as Abdih & Tsangarides (2008) and Candelon et al (2006).

Given that Hong Kong and Singapore are typical small open economies with similar major economic sectors: i.e. international bank and finance, international trade and logistic services, housing and construction, tourism and retailer, and high added value industries, I select the following four major economic fundamentals which play an essential role in determining the real exchange rate in Hong Kong and Singapore.

- Terms of trade (tot): ratio of export unit value index to the import counterpart
- Openness (open): ratio of import plus export over GDP
- Productivity (prod): ratio of real GDP per capita to the US counterpart
- Entrepot trade (rxp): ratio of re-exports data to the real GDP

Consequently the analysis treats the terms of trade, openness and entrepot trade data as the key factors which determine external balance, productivity as the essential proxy on the supply and demand sides of the internal balance for both the Hong Kong and Singapore economies. Thus we have

\[ BEER = f(tot, open, prod, rxp) \]

The misalignment of real exchange rate is calculated as follows:

\[ \text{Misalignment} = \frac{REER - BEER}{BEER} \approx \log(REER) - \log(BEER). \]
4.4.4 The data

- **Real effective exchange rate (REER)**
  Quarterly REER data are downloaded via the Bank of International Settlement’s (BIS) website. According to the definition from BIS, a nominal effective exchange rate (NEER) is an index of some weighted average of bilateral exchange rates. A real effective exchange rate (REER) is the NEER adjusted by some measure of relative prices or costs; changes in the REER thus take into account both nominal exchange rate developments and the inflation vis-à-vis trading partners. The weights are derived from manufacturing trade flows and capture both direct bilateral trade and third-market competition by double-weighting (Explanation on the double-weighting can be found in BIS Quarterly Review, March 2006). Also, BIS adopts time-varying weights in the REER calculation, in order to accommodate the rapidly changing trade patterns and to better represent the corresponding effects of exchange rate changes.

  Particularly, the REER data from BIS have made the trade data adjustment related to Mainland China and Hong Kong. According to the report from BIS, a substantial portion of Mainland China’s external trade takes place in the form of re-exports via Hong Kong, and official trade statistics of China and its trading partners do not consistently take this into account. Relative to ‘genuine’ (i.e. domestic demand/supply driven) trade flows, trade weights derived without a correction would assign an incorrect relative importance to Mainland China and to Hong Kong in the baskets of all currencies. For instance, in an unadjusted Hong Kong dollar REER basket, China would be overweighted and all others underweighted. Also for all other REER baskets, such as the REER of Singapore, Mainland China would be underweighted and Hong Kong would be overweighted. With these adjustments, the resulting REER are more representative of the final trade patterns and hence of competitiveness of the corresponding economies.

- **Source of other data**

  Remaining quarterly data are downloaded via Thomson’s Datastream. The origin of the Hong Kong data is the Censors and Statistics Department of Hong Kong and the Hong Kong Monetary Authority, and the origin of the Singapore data is the Singapore Statistics Department. Quarterly population data are constructed via interpolation. Seasonal fluctuations have been eliminated from all the real data.
• Brief description of the data
The quarterly data for Hong Kong are between 1985Q1 and 2007Q2, while the data for Singapore is between 1983Q1 and 2007Q2. The time span of the data is ideal for my empirical study, because Hong Kong implemented the Currency Board Arrangement in October 1983, while Singapore has been implementing a managed floating exchange rate regime. There are no fundamental changes in the two exchange rate regimes during this time span. The only concern is those years in which the Asian financial crisis hit the region and brought recession to the two economies. Evidence indicates that the empirical models of this study fit the data well in terms of the cointegration test without a crisis dummy for the crisis period. As a matter of fact, REER data itself had quickly adjusted for the economic environment during those periods. Similar evidence can be found in Rajan and Siregar (2002).

• Data plot
Figures 4-1 and 4-2 are data plots for Hong Kong and Singapore. First, in Panel A both REERs decreased from 1983 to 1988, and then enjoyed a ten-year increase until 1998 when the Asian financial crisis broke out. From 1998, both had to decline to regain competitive advantage. Singapore in particular experienced a sharply declining REER from 1986 to 1998, while the decline of REER in Hong Kong was relatively mild. Second, the plots of terms of trade (TOT) demonstrate deferent patterns in Panel B: while TOT in Singapore shows a steady declined trend, TOT in Hong Kong moves up and down within a relatively stable region. Third, both openness data shows a steady upward trend. Fourth, both productivity figures (ratio of gdppc against the US counterpart) increase overtime, except during the Asian financial crisis period. Hong Kong’s figure dropped below the trend more significantly in that period. Last, both re-exports figures (ratio of re-exports again the gdp data) demonstrate upward trends.
The Johansen cointegration method requires that at least some (not necessarily all) of variables be nonstationary, i.e. containing a unit root. I carry out both ADF test and P-P
test on my variables, and Table 4-2 and 4-3 indicate that all variables are nonstationary with a p-value noticeably greater than the 5% level, except the ADF test for the LREER of Singapore. Some may have concerns about the adequacy of the ADF and P-P tests given that there might be potential breaks during the Asian finance crisis period. These concerns seem to be unfounded. First, a glance at Figures 4-1 and 4-2 suggests that at least three of the fundamental variables (Openness, productivity, and re-exports data) exhibit obvious upward time trend, and the external shocks during the crisis period did not alter the trend. Second, most the p-values of the two tests are beyond 30%, which is far away from the significant level of 5%. Therefore, the VECM models are valid given that at least two of the endogenous and exogenous are not stationary.

**Table 4-2 Unit root test results for Hong Kong data (1985Q1-2007Q2)**

Null hypothesis: there is a unit root in the data

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF test p-values</th>
<th>PP test p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>lreer</td>
<td>0.8250</td>
<td>0.7032</td>
</tr>
<tr>
<td>ltot</td>
<td>0.4305</td>
<td>0.4305</td>
</tr>
<tr>
<td>lopen</td>
<td>0.3254</td>
<td>0.3508</td>
</tr>
<tr>
<td>lhk2usgdp</td>
<td>0.2855</td>
<td>0.3356</td>
</tr>
<tr>
<td>Lrxp2gdp</td>
<td>0.0920</td>
<td>0.0920</td>
</tr>
</tbody>
</table>

**Table 4-3 Unit root test results for Singapore data (1983Q1-2007Q2)**

Null hypothesis: there is a unit root in the data

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF test p-values</th>
<th>PP test p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>lreer</td>
<td>0.0310</td>
<td>0.2159</td>
</tr>
<tr>
<td>ltot</td>
<td>0.9399</td>
<td>0.9549</td>
</tr>
<tr>
<td>lopen</td>
<td>0.8644</td>
<td>0.9466</td>
</tr>
<tr>
<td>lsg2usgdp</td>
<td>0.8776</td>
<td>0.8775</td>
</tr>
<tr>
<td>Lrxp2gdp</td>
<td>0.9820</td>
<td>0.9827</td>
</tr>
</tbody>
</table>

- Cointegration test

I carry out cointegration tests on the above five variables for both models, including real effective exchange rate, terms of trade, openness, productivity and re-exports ratio. Johansen methods (both Trace and Max-Eigenvalue tests) have been applied and the results are enclosed in Appendices F.1 and F.3. In these tests, I adopt the ‘linear deterministic trend’ assumption in data according the pattern of the data plots. Moreover, I select ‘two lags’ for the lag intervals for the best cointegration results. Both tests results
support that there exists one cointegration equation in Hong Kong and Singapore models at **one percent significant level**. These results suggest that the cointegration relationships among five macro variables are significant in both empirical models.

It is worthwhile to point out that the cointegration result was relatively less significant if the re-exports data were dropped out from the cointegration equations. Therefore, evidence shows that the re-exports data are among the four major explanatory variables which have a significant cointegration relationship with the real effective exchange rates. Details of the test results can be found in Appendices F.2 and F.4.

### 4.4.5 The model

I set up the VECM models with two lags, based on two major reasons: First, it is consistent with the cointegration tests, in which there exists one cointegration relationship among the five variables with two lags at 1% level of significance. Second, the smallest AIC values are achieved in two lags. I list the cointegration equations for BEERs with the parameters of real exchange rates normalised by one. Suffix ‘L’ indicates that all variables in natural logs. All of the estimated parameters are statistically significant. I enclose the details of the error correction models estimates on Appendices F.5 and F.6.

**The Hong Kong model:**

\[
\text{Est}_L\text{REER} = -8.805 + 3.16*LTOT + 1.01*LOPEN + 0.19*LHK2USGDP - 0.97*LRXP2GDP
\]

\[
\text{[9.231]} \quad \text{[31.713]} \quad \text{[1.478]} \quad \text{[-17.484]}
\]

**The Singapore model:**

\[
\text{Est}_L\text{REER} = -0.101 + 1.16*LTOT - 3.34*LOPEN + 2.81*LSG2USGDP + 1.40*LRXP2GDP
\]

\[
\text{[4.327]} \quad \text{[-10.515]} \quad \text{[11.934]} \quad \text{[8.972]}
\]

*Standard errors in ( ) & t-statistics in [ ]*

In the above two empirical models, the estimated parameters are consistent with the theoretical models. First, the terms of trade (TOT) has a positive association with the real exchange rate. Improvement of terms of trade will drive the appreciation of real effective exchange rates (REERs) in the two economies. Second, productivities improved against the US counterpart (HK2USGDP & SG2USGDP) have a positive relationship with the REER which is consistent with the theory in which the Balassa-Samuelson effect. Third, as the theory could not offer a clear explanation of the impact of openness on REER, my
empirical models also suggest that openness (OPEN) can affect the REER in different ways according to different economies. While increased openness tends to appreciate REER in Hong Kong, increased openness depreciates REER in Singapore.

It is interesting to investigate the relationship of openness and re-export activities in depth. When Hong Kong’s economy was integrated with Mainland China, its manufacturing sectors relocated to the mainland. Nowadays Hong Kong has specialised in the trade-related service sector, such as finance, shipment and logistic services. The re-export data can capture these activities, while overall trade data (such as imports, exports and openness) fail to do so. My empirical model illustrates that openness tends to increase the REER in Hong Kong, given more robust export activities. However, without the re-export data, the openness figure alone will exaggerate its impact on Hong Kong’s REER, as a large proportion of its imports and exports activities belong to re-imports and re-exports for Mainland China. Therefore, the sign of parameters for the re-exports is opposite to the openness counterparts and mitigates the overall appreciation of REER.

The same situation can be found in Singapore’s model with different signs in the parameters in openness and re-exports. Evidence from the model suggests that increasing openness will lower the REER (given that imports dominate exports). However, re-exports tend to mitigate the depreciation of REER given that a significant part of those increase imports are re-exports to Malaysia or other countries. Therefore, the overall depreciation of REER will be moderate.

It is important to point out that without considering the impact of re-exports, the impact of openness on REER can be miscalculated for Hong Kong and Singapore, as these small open economies participate considerably in the entrepot trade activities. Therefore, my empirical models fill this gap in literature, which applies general explanatory variables for large economies but fails to look inside the special features of the two small economies, Hong Kong and Singapore.

So far I have addressed and answered my first set of research questions: What are the major economic fundamental variables for small open economies, which can explain the behaviour path of the REER? Particularly, have the entrepot trade variables played an important role in the empirical models of REER for Hong Kong and Singapore?

4.4.6 Misalignment analysis

Now it is necessary to conduct the misalignment analysis and address my second set of research questions: What is the overall performance of the two exchange regimes? Which
regime can create a stable macro environment in terms of a lower degree of REER misalignment and faster return to equilibrium? Did the currency board regime bring large-scale real exchange rate misalignments to Hong Kong?

First, I used the centred filtered method (with span = 2) to achieve the trend data of the four major explanatory variables in Rats software. Second, I use the cointegration equation to calculate the LBEER. Next, I plot the combined graphs of LBEER and actual LREER and analyse them. Meanwhile, I calculated the misalignment percentage series, which equals the difference between LREER and the estimated LBEER.

In the Hong Kong model, evidence reveals that the LREER moved considerably closed with the behavioural effective exchange rate (LBEER) in time, as depicted in Figure 4-3. From 1985 to 1989, both experienced decline in the movement. From 1989 to 1998, both enjoyed a steady incline in the Hong Kong, while both turned to a decline trend again after the Asian financial crisis in 1998. My findings are contrary to the traditional idea, in which fixed exchange rate regimes may suffer from a considerable REER misalignment because of the nominal exchange rate rigidity. On the contrary, Figure 4-3 illustrates that the actual LREER line moved largely in step with the LBEER, which represents the desired real exchange rate computed by the trend data of fundamental variables.

![Figure 4-3 The Hong Kong Model](image)

Source: LREER is from the BIS and LBEER is author’s estimation.

Are the misalignment estimates (in Figure 4-4) consistent with the major economic events? Yes, the figure shows the REER in Hong Kong was undervalued from 1985 to 1988, and from 1989 to 1997 the Hong Kong dollar was overvalued within a 10% range. Moreover, after the Asian financial crisis outbreak, the dollar has been mildly undervalued. Overall, the misalignment for Hong Kong is within plus or minus 10% range and
considered to be mild. The misalignment normally adjusts itself back to zero within two quarters, except the early years of the currency board regime from 1985 to 1988.

*Figure 4-4 REERs Misalignment Estimates for Hong Kong*

![Figure 4-4 REERs Misalignment Estimates for Hong Kong](image)

*Source: author’s calculation.*

In general, it is of interest to interpret the results of Hong Kong’s model, given that HKMA adopted Currency Board Arrangement and fixed the nominal exchange rate with the US dollar for more than two decades. My finding offers an unique perspective on the currency board regime, as some of the existing literature shows evidence of considerable large REER misalignment for Hong Kong, such as Rajan & Siregar (2002). There is no evidence in my empirical model to suggest that Hong Kong suffers from significant REER misalignment.

Figure 4-5 shows the co-movement of REER with the desired effective exchange rate BEER in Singapore from 1983 to 2007. There were noticeable sharp deviations of the two rates in 1986 when the Singapore government noticeably changed its policy to a managed appreciation. From 1992 to 1997, the years before the Asian financial crisis, the Singapore dollar was significantly below its fair value suggested by the BEER model.

*Figure 4-5 The Singapore Model*

![Figure 4-5 The Singapore Model](image)

*Source: LREER is from the BIS and LBEER is author’s estimation.*
Details of the REER misalignment estimates for Singapore can be found in Figure 4-6. The misalignment for Singapore is also within plus or minus 10% range, except some relative considerable misalignment observations in 1986 and 1994.

![Figure 4-6 REERs Misalignment Estimates for Singapore](image)

*Source: author’s calculation.*

Descriptive statistics for the misalignment estimates of both models are available in Table 4-4. Furthermore, statistics for the Singapore model without the outlier observations (1986Q1-Q4 & 1993Q4-1994Q1) are also examined, given that there were policy changes in Singapore during those periods. A glance at the statistics reveals that the standard deviation of the misalignment in Singapore is approximately 1.3% larger than the figure in Hong Kong. However, the standard deviation figures exhibit similarity when the outliers are removed in the Singapore model. Also most of the misalignment data fit in plus and minus 10% over time except the outliers. In general, there is no evidence to suggest that the misalignment for REER in Hong Kong is noticeable larger than that in Singapore, although different exchange rate regimes were implemented.

**Table 4-4 Descriptive statistics for the misalignment estimates**

<table>
<thead>
<tr>
<th></th>
<th>The Hong Kong model</th>
<th>The Singapore model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Original</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>4.78%</td>
<td>6.11%</td>
</tr>
<tr>
<td>Minimum</td>
<td>-11.28%</td>
<td>-18.91%</td>
</tr>
<tr>
<td>Maximum</td>
<td>9.21%</td>
<td>26.34%</td>
</tr>
</tbody>
</table>

*Source: author’s estimation.*

4.4.7 Goodness-of-fit tests

For both the BEER and NATREX approaches, the difference between the actual real exchange rate and the fitted values from the cointegration equation represents the
Chapter 4

misalignment from its desired /equilibrium level. Admittedly, the controversial argument is that the so-called misalignment might be just a specification error in the cointegration equation, which has limited ability to account for some of the relevant economic fundamentals. The defense of the BEER/NATREX approaches relies on some of the diagnostic tests imposed on the residuals of the VECM model. If the residuals are normally distributed and lack serial correlation, then one can conclude that there is no evidence of missing major explanatory variables and therefore the misalignment in the specified cointegration can be justified.

I test the stationary of the misalignment series, since the misalignment is defined as the difference between the estimated BEER and the actual REER. Given that these series are stationary, I can affirm that these models do not suffer from missing important explanatory variables. Relevant statistics reveal that both series are stationary at 5% level of significance.

The misalignment series for both Hong Kong and Singapore (Original & Outliers removed) all pass the Augmented Dickey Fuller and P-P stationary test at 5% level of significance. Therefore, there is no evidence that these models have a major misspecification problem.

4.4.8 A comparison of this study with the literature

Rajan & Siregar (2002) use ‘NATREX’ to represent the real effective exchange rate computed in BEER models. They also find huge fluctuations for Hong Kong in their NATREX series from 1984 to 1987, but could not offer a valid explanation for such huge fluctuations. I repeat their Figures in 4-7, 4-8 and 4-9 for reference. Their model fails to consider the impact of openness and entrepot trade on REER, but considers the impact of government spending and the US interest rate instead. Consequently, the computed NATREX, which represents the equilibrium effective exchange rate for Hong Kong, is unnecessarily volatile. Therefore, their conclusions for comparing the two exchange rate regimes are less convincing.

By comparison, this empirical study on the BEER does not contain such a volatile pattern in the period between 1985 and 1988. Instead, the data plots illustrate a consistent and stable pattern during the period observed. Moreover, while Rajan and Siregar offer evidence to show that Singapore performs better in terms of REER misalignment, my evidence supports the opposite conclusion. Although Hong Kong adopts a currency board regime, which fixed the nominal exchange rate, its real effective exchange rate can move
closely to the desired levels without huge misalignment. Therefore, my empirical models offer some reliable evidence which is in the favour of the currency board regime. These findings fill a gap in literature, which has ignored some special features of the two small open economies and suggested that the managed floating regime in Singapore performs better.

*Figure 4-7 NATREX and REER for Hong Kong (1990=100)*

*Source: Figure 5 in Rajan & Siregar (2002).*

*Figure 4-8 NATREX and REER for Singapore (1990=100)*

<table>
<thead>
<tr>
<th>NOTE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>This figure is included on page 112 of the print copy of the thesis held in the University of Adelaide Library.</td>
</tr>
</tbody>
</table>

*Source: Figure 6 in Rajan & Siregar (2002).*
It is interesting to further ask why Hong Kong REER performs well despite the rigidity in nominal exchange rate. The answer lies in the entrepot trade activities in which Hong Kong specialises. In the past twenty years, Mainland China has become one of the world’s major powerful manufacturing centres and the US is the largest export market for the Chinese products. Hong Kong is working as a middle man to facilitate such export activities, and consequently approximately 90% of its exports goods are actually re-exports from China to the US and the rest of the world. Entrepot trade activities deliver significant impacts on the REER in two ways. First they affect the nominal effective exchange rate which is calculated from trade weighted bilateral nominal exchange rates. Second they have impact on the inflation cycles of the Hong Kong. The two variables are the essential components in calculating REER. Therefore, the re-export activities are among those major driving forces which bring the REER consistent with the desired levels, although the nominal exchange rate is fixed.

4.5 Conclusion and policy implications
In this chapter, I have examined major approaches to model real exchange rates: the FEER, the NATREX and the BEER approaches and justified the use of the BEER approach in my study.
What are the major economic fundamental variables for small open economies, which can explain the behaviour path of the REER? Particularly, have the entrepot trade variables played an important role in the empirical models of REER for Hong Kong and Singapore?

In order to address the importance of the entrepot trade variable in my empirical models, I have analysed the trade figures in the introduction. Also I have addressed the importance of considering openness, terms of trade, and productivity variables in this study by reviewing the literature and theory. I follow the BEER approach to model the movement of real effective exchange in Hong Kong and Singapore and analysis the behavioural real exchange rate (BEER).

In the above two empirical models, the estimated parameters are consistent with the theoretical models. While terms-of-trade (TOT) has a positive association with the real exchange rate, improved productivity against the US counterpart exhibits a positive relationship with the REER. It is consistent with the theory in which the Balassa-Samuelson effect applies. This empirical study also suggests that openness (OPEN) can affect the REERs in different ways in different economies. While increased openness tends to appreciate REER in Hong Kong, increased openness depreciates REER in Singapore.

Moreover, I have further investigated the relationship of openness and re-export activities. I point out that re-export data can capture the trade patterns, while overall trade figures (such as imports, exports and openness figures) have limited ability to do so. My empirical model demonstrates that without the re-export data, the openness figure itself will exaggerate its impact on Hong Kong’s REER, as a large proportion of its import and export activities are characterized as re-imports and re-exports for Mainland China. Therefore, the sign of parameters for the re-exports is opposite to the openness counterparts and adjusts the overall appreciation of REER. The same situation was found in the Singapore’s model with different signs in the parameters in openness and re-exports.

I reveal that without considering the impact of re-exports, the impact of openness on REER can be miscalculated for Hong Kong and Singapore, as these small open economies participate considerably in entrepot trade activities. Therefore, this empirical study fills the gap in literature, which only applies general explanatory variables for large economies but fail to look inside the special features of the two small economies.
What is the overall performance of the two exchange regimes? Which regime can create a stable macro environment in terms of a lower degree of REER misalignment and faster return to equilibrium? Did the currency board regime bring large-scale real exchange rate misalignments to Hong Kong?

Interesting findings have been revealed in the misalignment analyses section. In the Hong Kong Model, evidence illustrates that the REER moved considerably closer to the behavioural effective exchange rate (BEER) over time. My findings are contradictory to the traditional ideas, in which fixed exchange rate regimes may suffer from considerable REER misalignment because of the nominal exchange rate rigidity. On the contrary, in the special case of Hong Kong, the actual REER line moves in step with the BEER, which represents the desired effective exchange rate computed by the trend data of fundamental variables. Moreover, the misalignment analysis in this study is consistent with major economic events. For instance, evidence shows that the Hong Kong dollar was overvalued by approximately 10% during the Asian financial crisis period in 1998.

My findings offer a unique perspective on the Hong Kong currency board regime, as some of the existing literature shows evidence of considerable large REER misalignment for Hong Kong, such as Rajan & Siregar (2002). By contrast, this study suggests that there is no evidence that Hong Kong suffers from a considerably large REER misalignment.

In the Singapore model, there also exists co-movement of REER with the desired effective exchange rate (BEER) in Singapore from 1983 to 2007, except during some volatile periods. I also examine the descriptive statistics on the misalignment estimates in Table 4-4. The statistics demonstrate that the standard deviation of the misalignment in Singapore is approximately 0.5% larger than the figure in Hong Kong. The volatility figures in terms of minimum and maximum observations are also relatively larger in Singapore.

I test the stationary of my misalignment series. Both models have passed the robustness test.

Last but not least, I have investigated the reason why Hong Kong’s REER perform well despite the rigidity in the nominal exchange rate. When Mainland China has become the world’s most powerful manufacturing centre and the US is the largest market for Chinese exports, Hong Kong works as a middle man to facilitate such export activities. Consequently almost 90% of its exports goods are actually re-export from China to the US. Such activities have two major impacts on the REER: nominal effective exchange rate and
Hong Kong’s inflation. The two variables are the essential constituents of REER. Therefore, the re-export activities are among those major driving forces which make the REER consistent with the desired levels, even though the nominal exchange rate is fixed.

In conclusion, after I consider the re-exports variable in my empirical models on REER, I reveal that the REER misalignment in Hong Kong is less significant when compared with the Singapore model. I have offered new evidence which supports the currency broad regime in Hong Kong.
Chapter 5
Conclusions

In my thesis studying the impact of a currency broad regime on Hong Kong’s economy, my aim is to search some useful but clear evidence on the performance of the regime and its impact on the economy. Three sets of interesting but related questions have been set up and carefully investigated in my empirical models.

5.1 Summary

Chapter one serves as an introduction chapter which links all three major chapters together, and offers the overall picture of my research. Before I commence my empirical modelling and analysis, I first review the uniqueness of the currency board regime and laissez-faire policy. Second, I provide a detailed review of Hong Kong’s economy under the currency board regime. Third, I offer a brief historical review of Hong Kong’s currency arrangements and the mechanism behind the currency board. At the end of the chapter, I shed light on the methodology to model Hong Kong’s economy under different exchange rate regimes, discuss my research interests in research questions and lay out my research outlook.

Part I

In chapter two, I have examined Hong Kong’s economy under different exchange rate regimes, and attempt to find empirical evidence to answer the following set of research questions:

Is there evidence from Hong Kong to suggest that the effect of aggregate demand shock on output is smaller under a flexible exchange rate than under a fixed exchange rate regime? Is this one of the major reasons why the recovery process of Hong Kong from the Asian financial crisis lasted longer compared with other Asian countries with a flexible exchange rate regime?
Following Bayoumi & Eichengreen (1994), I have chosen the output growth rate and inflation rate as explanatory variables in my first empirical model, and identified unrestricted VAR models on data from both the free-floating and currency board periods. I apply the Banchard and Quah restrictions (neutrality of money in the long-run) as the extra restrictions to recover my structural parameters. Furthermore, I follow Cecchetti’s model to release the unitary assumption in the structural residual matrix. While the Kwan & Lui (1996, 1999) models assume unitary variances in the error terms to recover their structural parameters, my empirical results show that the variances of error terms are considerably greater than one.

In the Impulse Response Functions (IRFs) and variance decomposition analysis, I have first compared the unrestricted VAR and structural VAR models for the free-floating period. Evidence suggests that the results are significantly different in the two models. The response of output growth to an aggregate demand shock has changed noticeably compared to that of the UVAR model. And the variance decomposition analysis also indicates the difference between these two models quantitatively. I analyse the importance of recovering the SVAR parameters. Second, I have compared IRFs and variance decomposition of the pre-crisis currency board model and the crisis-adjusted model. I find evidence that the pre-crisis model captures the economy better in both cases and therefore I select it as the baseline model for the currency board period. Third, I have illustrated that the IRFs analysis is consistent with the aggregate supply and demand framework.

Fourth, I have compared the free-floating and currency board SVAR models in details. I find convincing evidence to answer my first research question. Figures in the IRFs show that a positive aggregate demand (inflation) shock does increase prices and output in all SVAR models in the short-run. Moreover, evidence from IRFs does suggest that the effect of aggregate demand shock on output is smaller under flexible exchange rates than under fixed exchange rate regimes, although evidence from the crisis-adjusted model does not support the conclusion.

One of my interesting findings is the speed in which the model returns to steady-state after an output or inflation shock. Evidence suggests that the speeds of after-shock adjustment are significantly different across exchange rate regimes. I find that in the free-floating model, both output growth and inflation return to steady-state in a much shorter period. This finding suggests that a free-floating regime can cushion demand and supply shocks better than a currency board regime. The above findings provide a valid reason why the recovery process from the Asian financial crisis was much longer in Hong Kong.
compared with other Asian countries with a flexible exchange rate regime. These findings have not yet been reported in the literature I examined.

I have applied the sacrifice ratio analysis, which provides a quantitative measurement of the cumulative output change on the inflation gained after a positive demand shock. Furthermore, I also apply the bootstrapped method to compute the confidence intervals of the sacrifice ratio in order to provide convincing comparisons. The sacrifice ratios for Hong Kong are consistent over the periods I examine. Moreover, the sacrifice ratio is all negative (around -0.58, -1.23, -0.38) in the three SVAR models, with acceptable confidence intervals (compared with those in Cecchetti’s paper).

According to the aggregate supply and demand framework, a positive aggregate demand shock increases output and price level in the short-run. Following Cecchetti’s sacrifice ratio formula, the cumulative output growth in the numerator is positive and the sum of the inflation in the denominator is also positive. The framework suggests a positive ratio.

I have checked these ratios with the impulse response analyses in all my SVAR models, and found that they are consistent. Moreover, I analyse the reason why the ratios are negative in my SVAR models. The framework shows the overall effect of a positive aggregate demand shock on output growth and inflation; the IRFs divide the overall shock effect into quarterly responses. According to Cecchetti’s formula to calculate the sacrifice ratio, output is computed on a cumulative basis, which means the first quarter negative number will be counted repeatedly for most of the times, but following positive numbers are counted fewer times than the first negative number. The sum of the numerator turns out to be negative, and the denominator is positive. Therefore, the ratios for Hong Kong are negative in three SVAR models for Hong Kong.

Furthermore, evidence denotes that the sacrifice ratios in the pre-crisis currency board model are much larger in terms of absolute value, compared with those in the free-floating regime, although the ratios for the crisis-adjusted currency board model are smaller in terms of absolute value. The pre-crisis model is more reliable for the comparison.

In Cecchetti & Rich (2001), they estimate the sacrifice ratios in the United States on three different VAR models. I focus my comparison on the sacrifice ratio in one major model, called the Cecchetti model. The ratio in Cecchetti’s model is about 1.3 over 20 periods, with relatively small confidence intervals. I analyse the reason why Cecchetti’s sacrifice ratio is positive by looking at the IRFs of the model.
In conclusion, I have contributed to the literature by introducing the sacrifice ratio analyses to study Hong Kong’s economy. My evidence reveal that the ratio is larger (in absolute value) in the currency board period than that in the free-floating period, based on the evidence from the pre-crisis model. This evidence suggests that output will react to the aggregate demand shocks in a more volatile way under a fixed exchange rate regime.

*Which regime would have performed better in Hong Kong in terms of macro economy stability when I do a historical comparison of the free-floating period and the currency board period? What performance would the economy have delivered during 1974 and 1983 if a currency board regime had been implemented? On the contrary, how would the economy have performed during 1984-1996 if a free floating regime had been chosen?*

In my counter-factual analyses, I have included seasonal dummies in the exogenous section, and it is not necessary to make the seasonal adjustments in my endogenous variables (output growth and inflation). Both counter factual analyses indicate that under free-floating regimes, the fluctuations of output growth have been noticeably reduced, while the inflations are marginally higher. Moreover, free-floating regime generates higher levels of log output and log price in the counter factual analysis. I also compare my findings with Kwan and Lui’s model. In Kwan and Lui’s model, they find that currency board regimes generates smaller standard deviations in output growth and inflation; meanwhile, they also find that free-floating regimes make the log output and log price both achieve higher levels. I analyze the limitation in Kwan and Lui’s model and justify my findings.

In conclusion, my empirical evidence from Hong Kong suggests that output responded to an aggregate demand shock much faster in a flexible exchange rate regime than in a fixed exchange rate regime. The evidence provides one of the essential reasons why the recovering process of Hong Kong from the Asian Financial crisis lasted longer compared with the other Asian countries with a flexible exchange rate regime. Furthermore, my counter-factual analysis suggests that a free-floating regime can generate much smaller output variance in Hong Kong and deliver higher output and price levels to Hong Kong.
In chapter three, I have carried out further study Hong Kong’s economy under the Currency Board period (1984-2007) in consideration of the exogenous impact of the Chinese and US economies.

What are the major exogenous variables which deliver the impact of the US economy on Hong Kong?

I have answered this research question in Model I and investigated the major channels in which Hong Kong’s economy under the currency board regime is affected by the US economy. First, I have investigated the interest rate level of Hong Kong and find that it moves closely to its US counterpart across time except for some short-run deviation during the Asian financial crisis. The US interest rate plays a significant role in Hong Kong’s economy because of the fixed exchange rate arrangement. Secondly, I have analysed the real and nominal effective exchange rates between Hong Kong and the United States, and find that both Hong Kong’s changes in REER and NEER are highly correlated with their US counterpart. The correlation coefficients are 0.713 and 0.920 respectively. Therefore change in REER from the US is also a good exogenous variable which might have significant impact on Hong Kong’s economy. Furthermore, I have applied the US import data and US inflation data to capture the external aggregate demand and supply movement in Hong Kong.

Instead of following Genberg, Liu and Jin (2006)’s approach to put all the Hong Kong and the US data in the endogenous section to form a big SVAR system, I use my empirical model of Hong Kong’s output growth and inflation as a baseline model and subsequently consider more US data in the exogenous variable section in that model. This approach is more consistent with the real economy situation in Hong Kong. Moreover, it is capable to indentify those variables which deliver significant impacts on Hong Kong. First, I have considered the US imports and inflation data to the baseline UVAR model, and discovered that the explanatory power for the output equation has been significantly improved (4.3% increase), while the explanatory power for the inflation equation has been marginally reduced (0.6% decrease). Also I have tested the lag variables of US output growth and inflation in the model and find that they could not improve the model; therefore, only contemporary US variables will be considered. The intuitive explanation is that the US economy can deliver its full impact to Hong Kong within the same quarter (3 months).
Furthermore, I have examined the impacts of the US interest rate movement and the impact of the change of REER on Hong Kong. I find that both of them have improved the explanatory power of the output growth equation. These findings are consistent with the fact that under a fixed exchange rate regime, there exists a strong correlation between the US and Hong Kong interest rate. Moreover, the change of REER of Hong Kong is also highly correlated to the US counterpart. It is worthwhile to point out that adding more exogenous US explanatory variables to my study has failed to improve the explanatory power for Hong Kong’s inflation equation. My evidence suggests that the US economy has little impact on the inflation of Hong Kong.

*What are the key exogenous variables which can capture the close economic relationship between Mainland China and Hong Kong SAR?*

As a small open economy, Hong Kong flourishes in international trade and trade-related services such as finance, logistics and transportation. The most striking feature is that Hong Kong plays a very important role in the entrepot trade for Mainland China. Therefore, entrepot trade data can provide a good proxy of the close economic partnership with Mainland China. I examine Hong Kong entrepot trade patterns in detail and illustrate that the re-export activities in Hong Kong follow two-way directions. On one hand, Hong Kong helps China to export its products to the rest of the world; on the other hand, Hong Kong also assists China to import goods from the rest of the world.

In Model II I have used a similar approach. First I have considered contemporary growth data of re-exports to Mainland China and inflation data from WPI to the exogenous section in the model. I discover that this specification can only increase its explanatory power (approximately 1.8%) for Hong Kong’s output equation but decreases its explanatory power marginally (0.65) for the inflation equation.

Secondly, I have included the contemporary growth data of re-exports to all destinations and inflation data from WPI in the exogenous section of my empirical model. Interestingly I discover that the explanatory power of such a model has been significantly improved compared with the baseline model: more than 16% of the output growth variance and approximately 1.4% of the inflation variance can be explained by adding those two exogenous variables. It is worthwhile to point out that the specification has simultaneously improved the adjusted \( R^2 \) for both equations. The above evidence suggests that the re-
exports activities are essential for Hong Kong’s economy, and they represent Hong Kong’s close economic relationship with Mainland China.

I have investigated the reason why the data of all destinations have significantly improved the explanatory power compared with the data from Mainland China, although the correlation coefficient between the two re-exports data is considerably high (0.797). Evidence suggests that the quarterly growth data in 1985 are very volatile and the 1985 yearly data of re-exports to Mainland China can be characterised as an outlier. Therefore, I re-estimate Model II in specification (b) using a smaller sample and achieved more consistent and satisfactory adjusted-$R^2$ results. Compared with the baseline model without considering exogenous demand and supply factors, Model II using growth of the re-exports to China (1987-2007) provides additional 15% and 4% explanatory power to Hong Kong’s output growth and inflation equations. This evidence suggests that entrepot trade activities related to Mainland China do have significant impacts on Hong Kong’s economy.

Moreover, I have applied the first lag of growth data of re-exports to all destinations and inflation data from WPI in the exogenous section. Evidence suggests that these lag variables have reduced the explanatory power. It reveals that the impacts of exogenous demand and supply on Hong Kong’s economy are contemporary (within a quarter).

*Which of my two macroeconomic models can best capture the impact of external demand and supply on Hong Kong’s economy?*

I have compared Models I and II, which capture the impacts of the US and Chinese external aggregate demand and supply factors on Hong Kong’s economy. Evidence suggests that Model II provides a noticeably better explanatory power for Hong Kong’s output growth and inflation. Model II shows the importance of the Chinese economy which has a much closer link to Hong Kong than the US economy. My finding contradicts to some literature which concludes that the Chinese economy is much less significant than the US economy in explaining Hong Kong’s output variance.

Furthermore, I have applied the parameters of UVAR of Model II to recover the parameters of the SVAR. I have investigated whether the basic features of Hong Kong’s output growth and inflation have changed significantly when I consider re-exports and WPI data as the exogenous factors in the empirical model. I have analysed the impulse response functions, variance decomposition and sacrifice ratios of Model II, and compare
them with those in the baseline model, which did not consider external demand and supply factors. Evidence suggests that these features are very similar to those of the baseline model and no significant changes have been found. The basic conclusion is that the relationship of Hong Kong’s output growth and inflation remain stable, even when I consider the external demand and supply factors in the empirical model.

**Part III**

In Chapter four, I have examined some methodologies to model real exchange rates: the FEER and the BEER approaches and justify the use of the BEER approach in my study.

*What are the major economic fundamental variables for small open economies, which can explain the behavior path of the REER? Particularly, have the entrepot trade variables played an important role in the empirical models of REER for Hong Kong and Singapore?*

In order to address the importance of the enterpot trade variable in my empirical model, I have analysed the trade figures in the introduction. Also I have analysed the importance of considering openness, terms of trade, and productivity variables in this study by reviewing the literature and the theory. I follow the BEER approach to model the movement of real effective exchange in Hong Kong and Singapore and analyse the desired real exchange rate (BEER).

In the above two empirical models, the estimated parameters are consistent with the theoretical models. While terms-of-trade (TOT) has a positive association with the real exchange rate, improved productivity against the US counterpart has a positive relationship with the REER. It is consistent with the theory in which the Balassa-Samuelson effect applies. My empirical models also suggest that openness (OPEN) can affect the REER in different ways in different economies. While increased openness tends to appreciate REER in Hong Kong, increased openness depreciates REER in Singapore.

Moreover, I have further investigated the relationship of openness and re-export activities. I point out that re-export data can capture the trade patterns, while overall trade figures (such as imports, exports and openness figures) have limited ability to do so. My empirical model illustrates that without the re-export data, the openness figure itself will exaggerate its impact on Hong Kong’s REER, as a large proportion of its imports and exports activities are belong to re-imports and re-exports for Mainland China. Therefore, the sign of parameters for the re-exports is opposite to the openness counterparts and
adjusts the overall effects on REER. The same situation was found in the Singapore model with different signs in the parameters in openness and re-exports.

I show that without considering the impact of re-exports, the impact of openness on REER can be miscalculated for Hong Kong and Singapore, as these small open economies participate considerably in the entrerpot trade activities. Therefore, my empirical model fills the gap in literature, which only applies general explanatory variables for large economies but fail to look inside the special features of the two small economies.

What is the overall performance of the two exchange regimes? Which regime can create a stable macro environment in terms of a lower degree of REER misalignment and faster return to equilibrium? Did the currency board regime bring large-scale real exchange rate misalignments to Hong Kong?

Interesting findings have been revealed in the misalignment analyzes section. In the Hong Kong Model, evidence illustrates that the REER moved considerably closer to the behavioural effective exchange rate (BEER) over time. My findings are contradictory to traditional ideas, in which fixed exchange rate regimes may suffer from considerable REER misalignment because of the nominal exchange rate rigidity. On the contrary, in the special case of Hong Kong, the actual REER line moves in step with the BEER, which represents the desired effective exchange rate computed by the trend data of fundamental variables. Moreover, the misalignment analysis in this study is consistent with major economic events. For instance, evidence shows that the Hong Kong dollar was overvalued by approximately 10% during the Asian financial crisis period in 1998.

My findings offer a very different perspective on the currency board regime, as some of the existing literature shows evidence of considerable large REER misalignment for Hong Kong, such as Rajan & Siregar (2002). By contrast, my empirical model suggests that there is no evidence that Hong Kong suffers from considerably large REER misalignment.

In the Singapore model, there also exists co-movement of REER with the desired effective exchange rate (BEER) in Singapore from 1983 to 2007, except some volatile periods. I also examine the descriptive statistics on the misalignment estimates in Table 4-4. The statistics demonstrate that the standard deviation of the misalignment in Singapore is approximately 0.5% larger than the figure in Hong Kong. The volatility figures in terms of minimum and maximum observations are also relatively larger in Singapore.
I test the stationary of my misalignment series. Both models have passed the robustness test.

Last but not least, I have investigated the reason why Hong Kong’s REER perform well despite the rigidity in nominal exchange rate. When Mainland China has become the world’s most powerful manufacturing centre and the US is the largest market for Chinese exports, Hong Kong works as a middle man to facilitate such export activities. Consequently almost 90% of its exports goods are actually re-export from China to the US. Such activities have two major impacts on the REER: nominal effective exchange rate and Hong Kong’s inflation. The two variables are the essential constituent of REER. Therefore, the re-export activities are among those major driving forces which make the REER consistent with the desired levels, even though the nominal exchange rate is fixed.

In conclusion, after I consider the re-exports variable in my empirical models on REER, I discover that the REER misalignment in Hong Kong is less significant when compared with the Singapore model. I offer some new evidence which supports the Currency Broad regime in Hong Kong.

5.2 Major conclusions and findings

First, my first empirical model reveals that output returns to a steady state after an aggregate demand shock much faster in a flexible exchange rate regime than in a fixed exchange rate regime. My evidence offers an essential answer to the question why the recovering process of Hong Kong from the Asian financial crisis lasted longer compared with the other Asian countries with a flexible exchange rate regime. Furthermore, my counter-factual analysis suggests that a free-floating regime may generate a much smaller output variance in Hong Kong and deliver higher output and price levels to Hong Kong.

Second, my second empirical models reveal the importance of the Chinese economy which has a much closer link to Hong Kong than the US economy.

Third, after I consider the re-exports data in my empirical models on REER, the REER misalignment in Hong Kong has been found less significant when compared with the Singapore model. I offer some new evidence which supports the currency broad regime in Hong Kong.

My three empirical models indicate a story that although there are limitations in the currency broad regime in terms of relatively slow recovery from external demand shocks and relatively larger output variance, the regime is still a preferable choice for Hong Kong, especially when considering the closer economic link with Mainland China. In such an
economic relationship, China becomes a global major manufacturing centre and the United States is one of the major export destinations. Hong Kong acts as a middle man, and has specialised in facilitating international trade from China to the rest of the world. Moreover, there is no evidence in this study to suggest that the real exchange rate misalignment in Hong Kong was significantly larger under the currency board regime. Entrepot trade activities deliver significant impacts on the REER in two ways. First they affect the nominal effective exchange rate which is calculated from trade weighted bilateral nominal exchange rates. Second they have impact on the inflation cycles of the Hong Kong. The two variables are the essential components in calculating REER. Therefore, the re-export activities are among those major driving forces which bring the REER consistent with the desired levels, although the nominal exchange rate is fixed.

5.3 Further potential research topics

First, in chapter two, I only compare the impact of currency board and flexible exchange rate regimes on output growth and inflation. The structural shocks from output growth and inflation are considered to be supply and demand shocks respectively. Supply shocks are considered to deliver long-run impact on output growth, while demand shocks deliver only temporary impact on output growth. I apply this assumption to identify the parameters of my empirical model. In my future studies, I may apply other alternative restrictions to recover the parameters and compare the results. Moreover, I can further investigate the long-run growth model for Hong Kong by examining the long-run growth factors, such as technological progress, education, skilled labour migration and foreign direct investment. These are the supply side factors which can decide the long-run equilibrium growth path for Hong Kong.

Second, in chapter two I investigate the impact of China on Hong Kong’s output growth and inflation. So far the currency board regime is considered one of the reliable options for Hong Kong, as the United States is the major export destination for both Hong Kong and Mainland China. With the progress of the Closer Economic Partnership Agreement (CEPA) with Mainland China, Hong Kong has integrated its economy with Mainland China and specialised in the finance and entrepot trade service. A variety of interesting topics can be investigated, however, limited data are available so far at the early stage of CEPA. On the other hand, theoretical models may be an option to investigate the exchange rate choice of Hong Kong. Only when Mainland China opens its capital account
and its currency Reminbi becomes a major international reserve currency, Hong Kong may consider a switch from the currency board regime to a common Chinese currency.
Appendices

Appendix A

Theoretical models on a small open economy with flexibly and fixed exchange rate regimes from Walsh (2003)

A.1 A two-country AS-IS Model

The real exchange rate is defined as follows: \( \rho = s + p^* - p \), where \( s \) is the nominal exchange rate and \( p \) and \( p^* \) are the prices of home and foreign country.

Aggregate supply equations relate output to inflation surprises and real exchange rate as follows:

\[
y_t = -b_1 \rho_t + b_2 (\pi_t - E_{t-1} \pi_t) + e_t
\]
\[
y_t^* = b_1 \rho_t + b_2 (\pi_t^* - E_{t-1} \pi_t^*) + e_t^*.
\]

The IS equations represent the aggregate demand side of the economies, while LM equation is dispensed with by assuming the monetary authorities set inflation rate directly. Aggregate demand in each country is an increasing function of output in another country, and a real domestic depreciation (a rise in \( \rho \)) makes domestic goods less expensive relative to foreign goods and therefore shifts demand away from foreign output and towards home output. The variable \( \pi \) represents real interest rate. A rise in real interest rate in one country will depress the output. The variables \( u_t \) and \( u_t^* \) represent local and foreign demand shocks, while \( e_t \) and \( e_t^* \) represent local and foreign supply shocks. We have the aggregate demand equations as follows:

\[
y_t = a_1 \rho_t - a_2 \pi_t + a_3 y_t^* + u_t
\]
\[
y_t^* = -a_1 \rho_t - a_2 \pi_t^* + a_3 y_t + u_t^*.
\]

Finally, there is an uncovered interest rate parity condition equation:

\[
r_t = r_t^* + E_t \rho_{t+1} - \rho_t,
\]

which can be rearranged as:

\[
\rho_t = r_t^* - r_t + E_t \rho_{t+1}.
\]

A.2 A small open economy model with flexible exchange rate

The domestic economy of a small open economy has little impact on other economies, consequently foreign interest rate, output levels and inflation are treated as exogenous.

Aggregate supply: \( y_t = -b_1 \rho_t + b_2 (\pi_t - E_{t-1} \pi_t) + e_t \). (A.1)

Aggregate demand: \( y_t = a_1 \rho_t - a_2 \pi_t + u_t \). (A.2)

Uncovered real interest rate parity: \( \rho_t = r_t^* - r_t + E_t \rho_{t+1} \). (A.3)

Real exchange rate equation: \( \rho = s + p^* - p \). (A.4)

Consumer price index is the combination of home and foreign output prices:
Appendix

\[ q_t = hp_t + (1 - h)(s_t + p_t^*) \], where \( h \) is the share of domestic output in the consumer price index.

Real interest rate are defined by the Fisher relationship:

\[ r_t = i_t - E_t p_{t+1} + p_t. \]  \hspace{1cm} (A.5)

Uncovered nominal interest rate parity:

\[ i_t = E_t s_{t+1} - s_t + \dot{i}^*, \]  \hspace{1cm} (A.6)

where \( \dot{i}^* = r^* + E_t p_{t+1}^* - p_t^*. \) \hspace{1cm} (A.7)

Real money demand equation is assumed as follows:

\[ m_t - q_t = y_t - ci_t + v_t. \]  \hspace{1cm} (A.8)

The foundation of the above model is based on wage and price rigidity. Under a flexible exchange rate regime, nominal exchange rate is free to adjust.

Monetary policy is conducted by controlling nominal money supply:

\[ m_t = \mu + m_{t-1} + \varphi_t - \gamma \varphi_{t-1}, \hspace{0.5cm} 0 \leq \gamma \leq 1, \]  \hspace{1cm} (A.9)

where \( \varphi \) is a serially uncorrelated white noise process.

The model consisting A.1 to A.7 can be rearranged into two equations consisting only of the price level, nominal exchange rate and nominal money supply.

Foreign price shocks are assumed to follow a random white noise disturbance:

\[ p_t^* = \pi^* + p_{t-1}^* + \phi_t. \]  \hspace{1cm} (A.10)

we apply the method of undetermined coefficients and get the following solutions for \( p_t \) and \( s_t \), which are consistent with equations A.1 to A.7 and with rational expectations:

\[ p_t = k_0 + m_{t-1} + \frac{B_2 [1 + c(1 - \gamma)]}{K} \varphi_t - \gamma \varphi_{t-1} + \frac{[(A_2 - B_2)u_t - A_1 e_t - B_2 v_t]}{K} \]  \hspace{1cm} (A.11)

\[ s_t = d_0 + m_{t-1} + \frac{B_1 [1 + c(1 - \gamma)]}{K} \varphi_t - \gamma \varphi_{t-1} + \frac{[(B_1 - A_1)u_t + A_1 e_t + B_2 v_t]}{K}. \]  \hspace{1cm} (A.12)

where \( A_1 = h - a_1 - a_2 \), \( A_2 = 1 + C - A_1 > 0 \), \( B_1 = -(a_1 + a_2 + b_1 + b_2) < 0 \), \( B_2 = a_1 + a_2 + b_1 > 0 \), and \( K = -(1 + c)B_1 + b_2 A_1 \).

The constants:

\[ k_0 = (1 + c)\mu + \left[ c - \frac{a_2 (1 - h - b_1)}{a_1 + b_1}\right] \pi^*, \hspace{0.5cm} d_0 = k_0 - \pi^*. \]

From equation (A.11), we conclude that a flexible exchange rate can insulate the domestic economy from a foreign price shock \( \phi \), because neither \( p_{t-1}^* \) nor \( \phi_t \) enter equation (A.11) to affect domestic price level under a flexible exchange rate regime. Moreover, equation
Appendix

(A.12) shows both $p_{t-1}^*$ and $\phi_t$ affects nominal exchange rate while keeping the domestic currency price of foreign goods unchanged in terms of $s + p^*$. 

$\phi$ represents home country monetary shocks. We can prove $\frac{B_1[1 + c(1 - \gamma)]}{K} > 0$ and $\frac{B_1[1 + c(1 - \gamma)]}{K} > 0$, therefore a positive monetary shock increases the equilibrium price level and nominal exchange rate (domestic currency depreciation).

A.3 A small open economy model with fixed exchange rate

For a fixed exchange rate regime, a monetary authority commits its task to defend the fixed nominal exchange rate by buying or selling domestic currency when it is necessary. Nominal exchange rate is normalised to zero for all $t$: $s_t = 0$, and real exchange rate equals to the difference between domestic and foreign price levels: $\rho_t = p_t^* - p_t$.

The model also assumes that foreign price shocks follow a random white noise disturbance as equation (A.10):

$$t t p p \phi \pi + + = -1^*$$

We can solve the solution for price level, output and domestic real interest rate:

$$t tt tt u r a p p a y + - - = -2^*$$

Moreover, the money demand equation does not function in this case since money supply must adjust endogenously to defend the fixed exchange rate.

We can derive the following equation for $p_t$ using the methods of undetermined coefficients:

$$p_t = p_t^* - \frac{a_2 r^*}{a_1 + b_1} + \frac{u_t - e_t - b_2 \phi_t}{a_1 + a_2 + b_1 + b_2}.$$  

(A.16)

A.4 Comparing the two models

When we compare equation (A.11) and equation (A.16), we can find the following major differences between the fixed and flexible exchange rate systems.

Under fixed exchange rates, the average domestic rate of inflation is equal to the foreign inflation rate from equation (A.16):

$$E_t \pi_{t+1} = E_t (p_{t+1}^* - p_t) = E_t (p_{t+1}^* - p_t^*) = E_t \pi_{t+1}^*.$$
Therefore, foreign price levels \( p^* \) and foreign price shocks \( \phi \) affect domestic prices and output under a fixed exchange rate regime.

Aggregate supply and demand shocks will have a different effect on output according the different exchange rate regime. Under a flexible exchange rate regime, a positive aggregate demand shock increases price levels and real output. A rise in real interest rate and real appreciation can restore the good market equilibrium. The real appreciation can help to equilibrate goods markets and partially offset the rise in aggregated demand, i.e. a flexible exchange rate system can help to stabilise the aggregate output and reduce the validity of the output fluctuation. Therefore the effect of a demand shock on output is smaller under a flexible exchange rate regime then under a fixed exchange rate regime.

Appendix B

Selected empirical results for chapter 2

B.1 Dummy variable regression for the crisis-adjusted model

**Dependent Variable: GY01**
Method: Least Squares
Date: 06/28/08   Time: 18:02
Sample: 1984:1 2007:4
Included observations: 96

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<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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R-squared: 0.855480  Mean dependent var: 0.965997
Adjusted R-squared: 0.850768  S.D. dependent var: 6.005200
S.E. of regression: 2.319844  Akaike info criterion: 4.561651
Sum squared resid: 495.1143  Schwarz criterion: 4.668499
Log likelihood: -214.9592  F-statistic: 181.5306
Durbin-Watson stat: 1.737008  Prob(F-statistic): 0.000000

**Dependent Variable: PAI01**
Method: Least Squares
Date: 06/29/08   Time: 15:30
Sample: 1984:1 2007:4
Included observations: 96

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<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
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R-squared: 0.549566  Mean dependent var: 0.842253
Adjusted R-squared: 0.534877  S.D. dependent var: 1.660277
S.E. of regression: 1.312307  Akaike info criterion: 3.127165
Sum squared resid: 117.9549  Schwarz criterion: 3.234013
Log likelihood: -146.1039  F-statistic: 37.41575
Durbin-Watson stat: 2.115638  Prob(F-statistic): 0.000000
B.2 Lag order selection

VAR Lag Order Selection Criteria
Endogenous variables: GY01 PAI01
Exogenous variables: C Q1 Q2 Q3
Sample: 1974Q4 1983Q3
Included observations: 32

<table>
<thead>
<tr>
<th>Lag</th>
<th>LogL</th>
<th>LR</th>
<th>FPE</th>
<th>AIC</th>
<th>SC</th>
<th>HQ</th>
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</table>

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

VAR Lag Order Selection Criteria
Endogenous variables: GY01 PAI01
Exogenous variables: C Q1 Q2 Q3
Sample: 1984Q1 1996Q4
Included observations: 46

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* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
## B.3 Checking the model adequacy

### B.3.1 Free-floating Model

**VAR Residual Portmanteau Tests for Autocorrelations**

H0: no residual autocorrelations up to lag h  
Sample: 1974Q4 1983Q3  
Included observations: 34

<table>
<thead>
<tr>
<th>Lags</th>
<th>Q-Stat</th>
<th>Prob.</th>
<th>Adj Q-Stat</th>
<th>Prob.</th>
<th>df</th>
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<td>NA*</td>
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*The test is valid only for lags larger than the VAR lag order.  
df is degrees of freedom for (approximate) chi-square distribution*

**VAR Residual Serial Correlation LM Tests**

H0: no serial correlation at lag order h  
Sample: 1974Q4 1983Q3  
Included observations: 34

<table>
<thead>
<tr>
<th>Lags</th>
<th>LM-Stat</th>
<th>Prob</th>
</tr>
</thead>
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Probs from chi-square with 4 df.
VAR Residual Normality Tests
Orthogonalization: Cholesky (Lutkepohl)
H0: residuals are multivariate normal
Sample: 1974Q4 1983Q3
Included observations: 34

<table>
<thead>
<tr>
<th>Component</th>
<th>Skewness</th>
<th>Chi-sq</th>
<th>df</th>
<th>Prob.</th>
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<table>
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<th>Chi-sq</th>
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<th>Prob.</th>
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B.3.2 Pre-crisis Model

VAR Residual Portmanteau Tests for Autocorrelations
H0: no residual autocorrelations up to lag h
Sample: 1984Q1 1996Q4
Included observations: 50

<table>
<thead>
<tr>
<th>Lags</th>
<th>Q-Stat</th>
<th>Prob.</th>
<th>Adj Q-Stat</th>
<th>Prob.</th>
<th>df</th>
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<tr>
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</table>

*The test is valid only for lags larger than the VAR lag order.
df is degrees of freedom for (approximate) chi-square distribution
### VAR Residual Serial Correlation LM Tests

H0: no serial correlation at lag order $h$

Date: 05/27/09   Time: 14:01
Sample: 1984Q1 1996Q4
Included observations: 50

<table>
<thead>
<tr>
<th>Lags</th>
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Probs from chi-square with 4 df.

### VAR Residual Normality Tests

Orthogonalization: Cholesky (Lutkepohl)

H0: residuals are multivariate normal

Date: 05/27/09   Time: 14:31
Sample: 1984Q1 1996Q4
Included observations: 50

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<th>df</th>
<th>Prob.</th>
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<table>
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<tr>
<th>Component</th>
<th>Kurtosis</th>
<th>Chi-sq</th>
<th>df</th>
<th>Prob.</th>
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<td>0.2750</td>
</tr>
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</table>
Appendix C

Notes for Structural VAR analyses from Hamilton (1995)

C.1 Notes for Impulse Response Function

\[ X_t = C + D_1 X_{t-1} + D_2 X_{t-2} + \cdots + D_n X_{t-n} + U_t, \]

where \( C \) denotes an \((m \times 1)\) vector of constants and \( D_1 \) denotes an \((m \times m)\) matrix of autoregressive coefficients for \( j = 1, 2, \cdots, n \). The \((m \times 1)\) vector \( U_t \) is a vector generalization of white noise: 

\[ E(U_t) = 0, \quad E(U_t U_t') = \Omega, \]

with \( \Omega \) an \((m \times m)\) symmetric positive definite matrix.

Take expectations of both sides to calculate the mean 

\[ \mu = C + D_1 \mu + D_2 \mu + \cdots + D_n \mu \]

or 

\[ \mu = (I_n - D_1 - D_2 - \cdots - D_n)^{-1} C \].

\[ (X_t - \mu) = D_1 (X_{t-1} - \mu) + D_2 (X_{t-2} - \mu) + \cdots + D_n (X_{t-n} - \mu) + U_t. \]

It is helpful to rewrite \( VAR(n) \) in terms of \( VAR(1) \) process.

\[ \xi_t \equiv \begin{bmatrix} X_t - \mu \\ X_{t-1} - \mu \\ \vdots \\ X_{t-n} - \mu \end{bmatrix}, \quad FF \equiv \begin{bmatrix} D_1 & D_2 & D_3 & \cdots & D_{n-1} & D_n \\ I_x & 0 & 0 & \cdots & 0 & 0 \\ 0 & I_x & 0 & \cdots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & I_x & 0 \end{bmatrix}, \quad V_t \equiv \begin{bmatrix} U_t \end{bmatrix}, \]

The \( VAR(p) \) can now be rewritten as a \( VAR(1) \) process: 

\[ \xi_t = FF \xi_{t-1} + v_t, \]

where

\[ E(v_t v_t') = \begin{bmatrix} \Omega & 0 & \cdots & 0 \\ 0 & 0 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & 0 \end{bmatrix} \]

Equation (C.4) implies that

\[ \xi_{t+s} = v_{t+s} + FF v_{t+s-1} + FF^2 v_{t+s-2} + \cdots + FF^{s-1} v_{t+1} + FF^s \xi_t. \]

(C.5)

If the eigenvalues of FF all lie inside the unit circle, then the VAR turns out to be covariance-stationary.

The first \( m \) rows of the vector system represented in equation (C.5) constitutes a vector generalization as follow:

\[ X_{t+s} = \mu + U_{t+s} + \psi_1 U_{t+s-1} + \psi_2 U_{t+s-2} + \cdots + \psi_{s-1} U_{t+1} + FF_1^{(i)} (X_t - \mu) + FF_2^{(i)} (X_{t-1} - \mu) + \cdots + FF_{m-1}^{(i)} (X_{t-n+1} - \mu) \]

(C.6)

Here \( \psi_j = FF_1^{(i)} \) and \( FF_1^{(i)} \) denotes the upper left block of \( FF^i \), where \( FF^j \) is the matrix FF raised to the jth power—that is, the \((m \times m)\) matrix \( FF_1^{(i)} \) indicates rows 1 through \( n \) and columns 1 through \( n \) of the \((mn \times mn)\) matrix \( FF^i \). Similarly, \( FF_2^{(i)} \) denotes the block of \( FF^j \) consisting of rows 1 through \( n \) and columns \((m + 1)\) through \( 2m \), while \( FF_{m-1}^{(i)} \) denotes rows 1 through \( n \) and columns \([m(n-1) + 1]\) through \( mn \) of \( FF^i \).
If the eigenvalues of FF all lie inside the unit circle, then \( FF^s \to 0 \) as \( s \to \infty \) and \( X_t \) can be expressed as a convergent sum of the history of \( U \):
\[
X_t = \mu + U_t + \psi_1 U_{t-1} + \psi_2 U_{t-2} + \psi_3 U_{t-3} + \cdots \equiv \mu + \psi(L)U_t,
\]
which is a vector MA(\( \infty \)) representation.

Thus, the matrix \( \psi_s \) has the interpretation \( \frac{\partial X_{t+s}}{\partial U_t} = \psi_s \); that is, the row \( i \), column \( j \) element of \( \psi_s \) identifies the consequences of a one-unit increase in the \( j \)th variable’s innovation at date \( t \) \( (U_{j,t}) \) for the value of the \( i \)th variable at time \( t+s (X_{j,t+s}) \), holding all other innovations at all dates constant. A plot of the row \( i \), column \( j \) element of \( \psi_s \), \( t j \) \( s t i \) \( U \) \( X \), \( \partial \) \( \partial \) \( + \), as a function of \( s \) is called the impulse-response function. It describes the response of \( X_{j,t+s} \) to a one-time impulse in \( X_{j,t} \) with all other variables dated \( t \) or earlier held constant.

Note that from equation (C.7), \( X_{t-j} \) is a linear function of \( U_{t-j}, U_{t-j-1}, \ldots \), each of which is uncorrelated with \( X_{t-j} \) for any \( j \geq 0 \). Thus, the linear forecast of \( X_{t+j} \) on the basis of \( X_{t+j}, X_{t+j-1}, \ldots \) is given by \( \hat{X}_{t+j} = \mu + D_1(X_t - \mu) + D_2(X_{t-1} - \mu) + \cdots + D_n(X_{t-n+1} - \mu) \), and \( U_{t+j} \) can be interpreted as the fundamental innovation for \( X_{t+j} \), that is, the error in forecasting \( X_{t+j} \) on the basis of a linear function of a constant and \( X_t, X_{t-1}, \ldots \). More generally, it follows from equation (C.6) that a forecast of \( X_{t+j} \) on the basis of \( X_t, X_{t-1}, \ldots \) will take the form
\[
\hat{X}_{t+j} = \mu + F_{11}(X_t - \mu) + F_{12}(X_{t-1} - \mu) + \cdots + F_{1n}(X_{t-n+1} - \mu).
\]

C.2 Notes for Variance Decomposition

Remember that in the Unrestricted VAR model
\[
X_t = CC + D_1 X_{t-1} + D_2 X_{t-2} + \cdots + D_n X_{t-n} + U_t, \quad E(U_t U_t') = \begin{cases} \Omega, & t = \tau \\ 0, & t \neq \tau \end{cases}, \quad \text{with } \Omega \text{ an } (m \times m) \text{ symmetric positive definite matrix.}
\]
For any real symmetric positive definite matrix \( \Omega \), there exists a unique lower triangular matrix \( A \) with 1s along the principal diagonal and a unique diagonal matrix \( D \) with positive entries along the principal diagonal such that \( \Omega = A.D.D.A' \) (C.9). I can do a lower and upper decomposition on \( \Omega \) to get matrix \( A \) and \( DD \).

Using Matrix A I can construct an \( (m \times 1) \) vector \( E_t \) from \( E_t \equiv A^{-1}U_t \). Notice that since \( U_t \) is uncorrelated with its own lags or with lagged values of X, it follows that \( E_t \) is also uncorrelated with its own lags or with lagged values of X. The elements of \( E_t \) are furthermore uncorrelated with each other:
\[
E(E_t E_t') = [A^{-1}]E(U_t U_t')[A^{-1}'] = [A^{-1}][A^{-1}] = [A^{-1}]A.D.D.A'[A']^{-1} = DD.
\]
But DD is a diagonal matrix, verifying that the elements of \( E_t \) are mutually uncorrelated.

The \((j,j)\) element of \( DD \) gives the variance of \( U_{j,t} \).

From \( E_t \equiv A^{-1}U_t \), I have \( AE_t = U_t \).
Appendix

\[
\begin{bmatrix}
1 & 0 & 0 & \cdots & 0 \\
a_{21} & 1 & 0 & \cdots & 0 \\
a_{31} & a_{32} & 1 & \cdots & 0 \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
a_{n1} & a_{n2} & a_{n3} & \cdots & 1
\end{bmatrix}
\begin{bmatrix}
\epsilon_{1t} \\
\epsilon_{2t} \\
\epsilon_{3t} \\
\vdots \\
\epsilon_{nt}
\end{bmatrix}
= 
\begin{bmatrix}
u_{1t} \\
u_{2t} \\
u_{3t} \\
\vdots \\
u_{nt}
\end{bmatrix}.
\]

Equation (C.6) and (C.8) identify the error in forecasting a VAR \(s\) periods into the future as

\[
X_{t+s} - \hat{X}_{t+s} = U_{t+s} + \psi_1 U_{t+s-1} + \psi_2 U_{t+s-2} + \cdots + \psi_{s-1} U_{s-1}.
\]

The mean squared error of this \(s\)-period-ahead forecast is thus

\[
MSE(\hat{X}_{t+s}) = E[(X_{t+s} - \hat{X}_{t+s})(X_{t+s} - \hat{X}_{t+s})'] = \Omega + \psi_1 \Omega \psi_1' + \psi_2 \Omega \psi_2' + \cdots + \psi_{s-1} \Omega \psi_{s-1}'.
\]

where \(\Omega = E(U'U')\).

Write (C.11) as

\[
U_t = AE_t = a_1 \epsilon_{1t} + a_2 \epsilon_{2t} + \cdots + a_n \epsilon_{nt},
\]

where \(a_j\) denotes the \(j\)th column of the matrix \(A\) given in (C.9). Recalling that the \(\epsilon_{j,t}\)s are uncorrelated, postmultiplying equation (C.15) by its transpose and taking expectations produces

\[
\Omega = E(U'U') = a_1 V(a_1') + a_2 V(a_2') + \cdots + a_n V(a_n'),
\]

where \(V(a_{j,t})\) is the row \(j\), column \(j\) element of the matrix \(DD\) in (C.9). Substituting (C.17) into (C.14), the MSE of the \(s\)-period-ahead forecast can be written as the sum of \(n\) terms, one arising the each of the disturbances \(\epsilon_{j,t}\):

\[
MSE(\hat{X}_{t+s}) = \sum_{j=1}^n \{V(a_{j,t})[a_1 a_j' + \psi_1 a_j a_1' \psi_1' + \cdots + \psi_{s-1} a_j a_j' \psi_{s-1}']\}.
\]

With this expression, I can calculate the contribution of the \(j\)th orthogonalized innovation to the MSE of the \(s\)-period-ahead forecast:

As \(s \to \infty\) for a covariance-stationary VAR, \(MSE(\hat{X}_{t+s}) \to \Gamma_0\), the unconditional variance of the vector \(X_t\). Thus equation (C.18) permits calculation of the portion of the total variance of \(X_t\) that is due to the disturbance \(\epsilon\) by letting \(s\) become suitably large.

C.3 Bootstrapping method in calculating standard errors of nonorthogonalized impulse-response functions

Runkle (1987) employed a related approach based on bootstrapping. The idea behind bootstrapping is to obtain an estimated of the small-sample distribution of \(\hat{\pi}\) without assuming that the innovations \(\epsilon\) are Gaussian. To implement this procedure, first estimate the VAR and save the coefficient estimates \(\hat{\pi}\) and the fitted residuals \{\(\hat{\epsilon}_1, \hat{\epsilon}_2, \ldots, \hat{\epsilon}_T\)\}. Then consider an artificial random variable \(\epsilon_t\) that has the probability \(1/T\) of taking on each of the particular values \{\(\hat{\epsilon}_1, \hat{\epsilon}_2, \ldots, \hat{\epsilon}_T\)\}. The hope is that the distribution of \(\epsilon_t\) is similar to the distribution of the true population \(\epsilon_t\). Then take a random draw from this distribution (denoted \(u^{(1)}_t\)\), and use this to construct the first innovation in an artificial sample; that is, set

\[
y^{(1)}_t = \hat{\epsilon} + \hat{\Phi}_1 y_0 + \hat{\Phi}_2 y_{t-1} + \cdots + \hat{\Phi}_p y_{t-p+1} + u^{(1)}_t,
\]

\[
\hat{\epsilon} + \hat{\Phi}_1 y_0 + \hat{\Phi}_2 y_{t-1} + \cdots + \hat{\Phi}_p y_{t-p+1} + u^{(1)}_t;
\]

\[
\hat{\epsilon} + \hat{\Phi}_1 y_0 + \hat{\Phi}_2 y_{t-1} + \cdots + \hat{\Phi}_p y_{t-p+1} + u^{(1)}_t;
\]

\[
\hat{\epsilon} + \hat{\Phi}_1 y_0 + \hat{\Phi}_2 y_{t-1} + \cdots + \hat{\Phi}_p y_{t-p+1} + u^{(1)}_t;
\]

\[
\hat{\epsilon} + \hat{\Phi}_1 y_0 + \hat{\Phi}_2 y_{t-1} + \cdots + \hat{\Phi}_p y_{t-p+1} + u^{(1)}_t;
\]

\[
\hat{\epsilon} + \hat{\Phi}_1 y_0 + \hat{\Phi}_2 y_{t-1} + \cdots + \hat{\Phi}_p y_{t-p+1} + u^{(1)}_t;
\]

\[
\hat{\epsilon} + \hat{\Phi}_1 y_0 + \hat{\Phi}_2 y_{t-1} + \cdots + \hat{\Phi}_p y_{t-p+1} + u^{(1)}_t;
\]
Where \( y_0, y_{-1}, \ldots, y_{-p} \) denote the presample values of \( y \) that were actually observed in the historical data. Taking a second draw \( u^{(1)}_2 \), generate
\[
y^{(1)}_2 = \hat{c} + \hat{\Phi}_1 y_1 + \hat{\Phi}_2 y_0 + \ldots + \hat{\Phi}_p y_{-p+2} + u^{(1)}_2.
\]
Note that this second draw is with replacement; that is, there is a \((1/T)\) chance that \( u^{(1)}_1 \) is exactly the same as \( u^{(1)}_2 \). Proceeding in this fashion, a full sample \( \{y^{(1)}_1, y^{(1)}_2, \ldots, y^{(1)}_T\} \) can be generated. A VAR can be fitted by OLS to these simulated data (again taking presample values of \( y \) as their historical values), producing an estimate \( \hat{\pi}^{(1)} \). From this estimate, the magnitude \( \psi_s(\hat{\pi}^{(1)}) \) can be calculated. Next, generate a second set of \( T \) draws from the distribution of \( u \), denoted \( \{u^{(2)}_1, u^{(2)}_2, \ldots, u^{(2)}_T\} \), fit \( \hat{\pi}^{(2)} \) to these data by OLS, and calculated \( \psi_s(\hat{\pi}^{(2)}) \). A series of 10,000 such simulation could be undertaken, and a 95% confidence interval for \( \psi_s(\hat{\pi}^{(1)}) \) is then inferred from the range that includes 95% of the values for \( \psi_s(\hat{\pi}^{(2)}) \).
Appendix D
Selected Unrestricted & Structural VAR analyses for chapter 2: impulse response functions, variance decomposition & sacrifice ratios

D.1 Impulse response functions for Currency Board Periods (UVAR)
UVAR 1984-1996

UVAR 1984-2007
Appendix

D.2 Variance decomposition (UVAR)
Unrestricted VAR
Variance decomposition for the currency-board regime (1984-1996)

<table>
<thead>
<tr>
<th>Period</th>
<th>Output shocks ($u^y_t$)</th>
<th>Inflation shocks ($u^p_t$)</th>
<th>Period</th>
<th>Output shocks ($u^y_t$)</th>
<th>Inflation shocks ($u^p_t$)</th>
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Unrestricted VAR
Variance decomposition for the currency-board regime (1984-2007)

<table>
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<th>Inflation shocks ($u^p_t$)</th>
<th>Period</th>
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D.3 Sacrifice ratios
Sacrifice ratio estimates for the free-floating regime (1974-1984)
SVAR

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Sacrifice ratio estimates for currency board regime (pre-crises period 1984-1996)

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Sacrifice ratio estimates for currency board regime (1984-2007)

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Sacrifice ratio estimates for the currency board regime (1984-2007)

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Appendix E

Notes for VECM models from Clark & MacDonald (1998) with some amendments

Define an (nx1) vector of variables, $x_t$, consisting of the non-stationary variables (exchange rate and other macro variables) and assume that it has a vector autoregressive representation of the form:

$$ x_t = \eta + \sum_{i=1}^{p} \Pi x_{t-i} + \varepsilon_t \quad (E.1). $$

Where $\eta$ is a (nx1) vector of deterministic variables, and $\varepsilon$ is a (nx1) vector of white noise disturbances, with mean zero and covariance matrix $\Xi$. Expression (E.1) may be reparameterized into the vector error correction mechanism (VECM) representation as:

$$ \Delta x_t = \eta + \sum_{i=1}^{p} \Phi_i \Delta x_{t-i} - \Pi x_{t-1} + \varepsilon_t \quad (E.2), $$

where $\Delta$ denotes the first difference operator, $\Phi_i$ is a (nxn) coefficient matrix (equal to $-\sum_{j=1}^{p} \Pi - I$), $\Pi$ is a (nxn) matrix (equal to $-\sum_{i=1}^{p} \Pi_j - I$) whose rank determines the number of cointegrating vectors. If is of either full rank, n, or zero rank, $\Pi = 0$, there will be no cointegration amongst the elements in the long-run relationship. In these two cases it will be appropriate to estimate the model in first differences. If, however, $\Pi$ is of reduced rank, $r$, where $r<n$, then there will exist (nxr) matrices $\alpha$ and $\beta$ such that $\beta \alpha' = \Pi$, where $\alpha$ is the matrix whose columns are the linearly independent cointegrating vectors and the $\alpha$ matrix is interpreted as the adjustment matrix, indicating the speed with which the system responds to last period’s deviation from the equilibrium level of the exchange rate. Hence the existence of the VECM model relative to a VAR model in first differences depends upon the existence of cointegration.

One can test for the existence of cointegration amongst the variables contained in $x_t$ using the Trace test as proposed by Johansen (1995). For the hypothesis that there are at most $r$ distinct cointegrating vectors, this has the form:

$$ TR = T \sum_{i=r+1}^{N} \ln(1 - \hat{\lambda}_i) \quad (E.3), $$

Where $\hat{\lambda}_{r+1}, \ldots, \hat{\lambda}_N$ are the N-r smallest squared canonical correlations between $x_{t-k}$ and $\Delta x_t$ series (where at least some the variables entering $x_t$ x are assumed I(1)), corrected for the effect of lagged difference of the $x_t$ process. The method for extracting the $\lambda$’s is described in Johansen (1998) and Johansen and Juselius (1991).
Appendix F
Cointegration tests and VECM estimates for chapter four

F.1 Cointegration tests for all 5 variables: the Hong Kong model
Sample (adjusted): 1985Q4 2007Q2
Included observations: 87 after adjustments
Trend assumption: Linear deterministic trend
Series: LREER LTOT LOPEN LHK2USGDP LRXP2GDP
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

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<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
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<tr>
<td>None *</td>
<td>0.426650</td>
<td>93.52058</td>
<td>69.81889</td>
<td>0.0002</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.219027</td>
<td>45.12609</td>
<td>47.85613</td>
<td>0.0883</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.139932</td>
<td>23.61836</td>
<td>29.79707</td>
<td>0.2170</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.071407</td>
<td>10.50369</td>
<td>15.49471</td>
<td>0.2440</td>
</tr>
<tr>
<td>At most 4 *</td>
<td>0.045576</td>
<td>4.058292</td>
<td>3.841466</td>
<td>0.0439</td>
</tr>
</tbody>
</table>

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.426650</td>
<td>48.39449</td>
<td>33.87687</td>
<td>0.0005</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.219027</td>
<td>21.50773</td>
<td>27.58434</td>
<td>0.2467</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.139932</td>
<td>13.11467</td>
<td>21.13162</td>
<td>0.4417</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.071407</td>
<td>6.445400</td>
<td>14.26460</td>
<td>0.5567</td>
</tr>
<tr>
<td>At most 4 *</td>
<td>0.045576</td>
<td>4.058292</td>
<td>3.841466</td>
<td>0.0439</td>
</tr>
</tbody>
</table>

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
### F.2 Cointegration tests without re-exports data: the Hong Kong model

Sample (adjusted): 1985Q4 2007Q2  
Included observations: 87 after adjustments  
Trend assumption: Linear deterministic trend  
**Series:** LREER LTOT LOPEN LHK2USGDP  
Lags interval (in first differences): 1 to 2

#### Unrestricted Cointegration Rank Test (Trace)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.259518</td>
<td>47.17490</td>
<td>47.85613</td>
<td>0.0579</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.151494</td>
<td>21.03545</td>
<td>29.79707</td>
<td>0.3554</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.050831</td>
<td>6.743275</td>
<td>15.49471</td>
<td>0.6077</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.025023</td>
<td>2.204662</td>
<td>3.841466</td>
<td>0.1376</td>
</tr>
</tbody>
</table>

*Trace test indicates no cointegration at the 0.05 level*

* denotes rejection of the hypothesis at the 0.05 level  
**MacKinnon-Haug-Michelis (1999) p-values*  

#### Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.259518</td>
<td>26.13945</td>
<td>27.58434</td>
<td>0.0756</td>
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<tr>
<td>At most 1</td>
<td>0.151494</td>
<td>14.29217</td>
<td>21.13162</td>
<td>0.3415</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.050831</td>
<td>4.538613</td>
<td>14.26460</td>
<td>0.7986</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.025023</td>
<td>2.204662</td>
<td>3.841466</td>
<td>0.1376</td>
</tr>
</tbody>
</table>

*Max-eigenvalue test indicates no cointegration at the 0.05 level*

* denotes rejection of the hypothesis at the 0.05 level  
**MacKinnon-Haug-Michelis (1999) p-values*
### F.3 Cointegration tests for all 5 variables: the Singapore model

Sample (adjusted): 1983Q4 2007Q2
Included observations: 95 after adjustments
Trend assumption: Linear deterministic trend

**Series:** LREER LTOT LOPEN LSG2UGDP LRXP2GDP
Lags interval (in first differences): 1 to 2

#### Unrestricted Cointegration Rank Test (Trace)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Trace Eigenvalue</th>
<th>Trace Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.347881</td>
<td>83.41958</td>
<td>69.81889</td>
<td>0.0028</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.209336</td>
<td>42.80444</td>
<td>47.85613</td>
<td>0.1374</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.149029</td>
<td>20.49070</td>
<td>29.79707</td>
<td>0.3902</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.052684</td>
<td>5.159826</td>
<td>15.49471</td>
<td>0.7916</td>
</tr>
<tr>
<td>At most 4</td>
<td>1.31E-06</td>
<td>0.000124</td>
<td>3.841466</td>
<td>0.9926</td>
</tr>
</tbody>
</table>

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

#### Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Max-Eigen Eigenvalue</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None *</td>
<td>0.347881</td>
<td>40.61513</td>
<td>33.87687</td>
<td>0.0068</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.209336</td>
<td>22.31375</td>
<td>27.58434</td>
<td>0.2047</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.149029</td>
<td>15.33087</td>
<td>21.13162</td>
<td>0.2664</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.052684</td>
<td>5.159702</td>
<td>14.26460</td>
<td>0.7215</td>
</tr>
<tr>
<td>At most 4</td>
<td>1.31E-06</td>
<td>0.000124</td>
<td>3.841466</td>
<td>0.9926</td>
</tr>
</tbody>
</table>

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
F.4 Cointegration tests without re-exports data: the Singapore model

Sample (adjusted): 1983Q4 2007Q2
Included observations: 95 after adjustments
Trend assumption: Linear deterministic trend
Series: LREER LTOT LOPEN LSG2USGDP
Lags interval (in first differences): 1 to 2

Unrestricted Cointegration Rank Test (Trace)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvalue</th>
<th>Trace Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.205921</td>
<td>43.03123</td>
<td>47.85613</td>
<td>0.1318</td>
</tr>
<tr>
<td>At most 1</td>
<td>0.147178</td>
<td>21.12688</td>
<td>29.79707</td>
<td>0.3498</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.059041</td>
<td>6.002465</td>
<td>15.49471</td>
<td>0.6953</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.002325</td>
<td>0.221159</td>
<td>3.841466</td>
<td>0.6382</td>
</tr>
</tbody>
</table>

Trace test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

<table>
<thead>
<tr>
<th>Hypothesized No. of CE(s)</th>
<th>Eigenvaue</th>
<th>Max-Eigen Statistic</th>
<th>0.05 Critical Value</th>
<th>Prob.**</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0.205921</td>
<td>21.90435</td>
<td>27.58434</td>
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<tr>
<td>At most 1</td>
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<td>15.12442</td>
<td>21.13162</td>
<td>0.2803</td>
</tr>
<tr>
<td>At most 2</td>
<td>0.059041</td>
<td>5.781306</td>
<td>14.26460</td>
<td>0.6415</td>
</tr>
<tr>
<td>At most 3</td>
<td>0.002325</td>
<td>0.221159</td>
<td>3.841466</td>
<td>0.6382</td>
</tr>
</tbody>
</table>

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
## F.5 Vector error correction estimates for the Hong Kong model

### Vector Error Correction Estimates

Sample (adjusted): 1985Q4 2007Q2

Included observations: 87 after adjusting endpoints

Standard errors in () & t-statistics in []

<table>
<thead>
<tr>
<th>Cointegrating Eq</th>
<th>CointEq1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LREER(-1)</td>
<td>1.000000</td>
</tr>
<tr>
<td>LTOT(-1)</td>
<td>-3.155044</td>
</tr>
<tr>
<td></td>
<td>(0.34181)</td>
</tr>
<tr>
<td></td>
<td>[-9.23051]</td>
</tr>
<tr>
<td>LOPEN(-1)</td>
<td>-1.008218</td>
</tr>
<tr>
<td></td>
<td>(0.03179)</td>
</tr>
<tr>
<td></td>
<td>[-31.7125]</td>
</tr>
<tr>
<td>LHK2USGDP(-1)</td>
<td>-0.189878</td>
</tr>
<tr>
<td></td>
<td>(0.12850)</td>
</tr>
<tr>
<td></td>
<td>[-1.47760]</td>
</tr>
<tr>
<td>LRXP2GDP(-1)</td>
<td>0.969032</td>
</tr>
<tr>
<td></td>
<td>(0.05542)</td>
</tr>
<tr>
<td></td>
<td>[17.4843]</td>
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<tr>
<td>C</td>
<td>8.805020</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Error Correction:</th>
<th>D(LREER)</th>
<th>D(LTOT)</th>
<th>D(OPEN)</th>
<th>D(LHK2USGDP)</th>
<th>D(LRXP2GDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CointEq1</td>
<td>0.351744</td>
<td>0.079900</td>
<td>0.358693</td>
<td>-0.053556</td>
<td>-0.359356</td>
</tr>
<tr>
<td></td>
<td>(0.09290)</td>
<td>(0.02077)</td>
<td>(0.14762)</td>
<td>(0.04989)</td>
<td>(0.11284)</td>
</tr>
<tr>
<td>D(LREER(-1))</td>
<td>-0.018148</td>
<td>0.012490</td>
<td>-0.470727</td>
<td>0.019476</td>
<td>0.109037</td>
</tr>
<tr>
<td></td>
<td>(0.15938)</td>
<td>(0.03564)</td>
<td>(0.25326)</td>
<td>(0.08560)</td>
<td>(0.19359)</td>
</tr>
<tr>
<td></td>
<td>[-0.11387]</td>
<td>[0.35048]</td>
<td>[-1.85869]</td>
<td>[0.22753]</td>
<td>[0.56324]</td>
</tr>
<tr>
<td>D(LREER(-2))</td>
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<td>-0.053713</td>
<td>-0.259293</td>
<td>-0.106348</td>
<td>-0.066882</td>
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<tr>
<td></td>
<td>(0.15249)</td>
<td>(0.03410)</td>
<td>(0.24232)</td>
<td>(0.08190)</td>
<td>(0.18523)</td>
</tr>
<tr>
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<td>[-1.57522]</td>
<td>[-1.07003]</td>
<td>[-1.29846]</td>
<td>[-0.36108]</td>
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<tr>
<td>D(LTOT(-1))</td>
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<td>-0.063578</td>
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<td>-0.550859</td>
<td>-0.868756</td>
</tr>
<tr>
<td></td>
<td>(0.51004)</td>
<td>(0.11405)</td>
<td>(0.81049)</td>
<td>(0.27394)</td>
<td>(0.61953)</td>
</tr>
<tr>
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<td>[-0.55747]</td>
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<td>[-2.01089]</td>
<td>[-1.40228]</td>
</tr>
<tr>
<td>D(LTOT(-2))</td>
<td>0.117914</td>
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<td>0.248575</td>
<td>1.317240</td>
</tr>
<tr>
<td></td>
<td>(0.52813)</td>
<td>(0.11809)</td>
<td>(0.83923)</td>
<td>(0.28365)</td>
<td>(0.64150)</td>
</tr>
<tr>
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<td>[0.22327]</td>
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<td>[0.37377]</td>
<td>[0.87634]</td>
<td>[2.05338]</td>
</tr>
<tr>
<td></td>
<td>D(LOPEN(-1))</td>
<td>D(LOPEN(-2))</td>
<td>D(LHK2USGDP(-1))</td>
<td>D(LHK2USGDP(-2))</td>
<td>D(LRXP2GDP(-1))</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------</td>
<td>-----------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td></td>
<td>0.248119 (0.08885)</td>
<td>0.140766 (0.06727)</td>
<td>0.029154 (0.21470)</td>
<td>0.321893 (0.18860)</td>
<td>-0.236906 (-0.09720)</td>
</tr>
<tr>
<td></td>
<td>0.040543 (0.01987)</td>
<td>0.000262 (0.01504)</td>
<td>0.038676 (0.04801)</td>
<td>0.064652 (0.02173)</td>
<td>-0.48101 (-0.02173)</td>
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<tr>
<td></td>
<td>-0.372053 (0.14118)</td>
<td>-0.201559 (0.15445)</td>
<td>0.250726 (0.29969)</td>
<td>-0.025572 (0.14414)</td>
<td>0.407558 (0.45956)</td>
</tr>
<tr>
<td></td>
<td>0.012326 (0.04772)</td>
<td>0.0003031 (0.05220)</td>
<td>0.189660 (0.11531)</td>
<td>0.050950 (0.04782)</td>
<td>0.049612 (0.04872)</td>
</tr>
<tr>
<td></td>
<td>-0.406099 (0.10793)</td>
<td>-0.230587 (0.26079)</td>
<td>0.139151 (0.22908)</td>
<td>0.725852 (0.22908)</td>
<td>0.218370 (0.11806)</td>
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<tr>
<td></td>
<td>[2.79242 (2.04057)]</td>
<td>[2.09258 (0.01748)]</td>
<td>[1.70677 (1.53307)]</td>
<td>[1.70677 (1.53307)]</td>
<td>[-2.21324 (2.63877)]</td>
</tr>
<tr>
<td></td>
<td>[-2.63502 (1.88558)]</td>
<td>[-0.372053 (0.73489)]</td>
<td>[2.04057 (0.73489)]</td>
<td>[1.94985 (2.63784)]</td>
<td>[0.95037 (2.63784)]</td>
</tr>
<tr>
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<td>[0.25829 [-3.76267]]</td>
<td>[0.08388 [-2.82203]]</td>
<td>[0.08388 [-2.82203]]</td>
<td>[0.08388 [-2.82203]]</td>
<td>[0.08388 [-2.82203]]</td>
</tr>
</tbody>
</table>

|                  |                       |                       |                           |                           |                           |                           |                     |
|                  | R-squared             | 0.289562 (0.185364)   | 0.369872 (0.277453)       | 0.493570 (0.419293)       | 0.407558 (0.45956)        | -0.025572 (0.14414)       | -0.001357 (0.00071)  |
|                  | Adj. R-squared        | 0.289562 (0.185364)   | 0.369872 (0.277453)       | 0.493570 (0.419293)       | 0.407558 (0.45956)        | -0.025572 (0.14414)       | -0.001357 (0.00071)  |
|                  | Sum sq. resid         | 0.049003 (0.049003)   | 0.002450 (0.002450)       | 0.123738 (0.123738)       | 0.194985 (0.194985)       | 0.013254 (0.013254)       | 0.002993 (0.002993)  |
|                  | S.E. equation         | 0.025561 (0.025561)   | 0.005716 (0.005716)       | 0.040618 (0.040618)       | 0.005716 (0.005716)       | 0.013254 (0.013254)       | 0.002993 (0.002993)  |
|                  | F-statistic           | 2.778970 (202.0101)   | 4.002129 (322.3248)       | 6.645040 (616.7164)       | 6.407558 (6.143248)       | 0.013254 (0.013254)       | 0.002993 (0.002993)  |
|                  | Log likelihood        | 202.0101 (202.0101)   | 322.3248 (322.3248)       | 616.7164 (616.7164)       | 6.143248 (6.143248)       | 0.013254 (0.013254)       | 0.002993 (0.002993)  |
|                  | Akaike AIC            | -4.368048 (-3.763788) | -7.363788 (-3.441757)     | -3.441757 (-5.611231)     | -3.441757 (-5.611231)     | -3.441757 (-5.611231)     | -3.441757 (-5.611231) |
|                  | Schwarz SC            | -4.27923 (-4.27923)   | -7.23663 (-7.23663)       | -3.101632 (-5.271106)     | -3.101632 (-5.271106)     | -3.101632 (-5.271106)     | -3.101632 (-5.271106) |
|                  | Mean dependent        | -0.000133 (-0.000133) | -0.000837 (-0.000837)     | 0.013373 (0.013373)       | 0.013373 (0.013373)       | 0.013373 (0.013373)       | 0.013373 (0.013373)   |
|                  | S.D. dependent        | 0.028320 (0.115257)   | 0.006724 (0.006724)       | 0.053302 (0.053302)       | 0.053302 (0.053302)       | 0.053302 (0.053302)       | 0.053302 (0.053302)   |

|                  | Determinant resid covariance (dof adj.) | 4.50E-18 |
|                  | Determinant resid covariance                  | 2.14E-18 |
|                  | Log likelihood                                 | 1152.574 |
|                  | Akaike information criterion                   | -25.00171 |
|                  | Schwarz criterion                              | -23.15936 |

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## F.6 Vector error correction estimates for the Singapore model

Sample (adjusted): 1983Q4 2007Q2  
Included observations: 95 after adjustments  
Standard errors in ( ) & *-statistics in [ ]

<table>
<thead>
<tr>
<th>Cointegrating Eq:</th>
<th>CointEq1</th>
</tr>
</thead>
<tbody>
<tr>
<td>LREER(-1)</td>
<td>1.000000</td>
</tr>
<tr>
<td>LTOT(-1)</td>
<td>-1.159236 (0.26793) [-4.32661]</td>
</tr>
<tr>
<td>LOPEN(-1)</td>
<td>3.343818 (0.31802) [ 10.5146]</td>
</tr>
<tr>
<td>LSG2USGDP(-1)</td>
<td>-2.808577 (0.23534) [-11.9341]</td>
</tr>
<tr>
<td>LRXP2GDP(-1)</td>
<td>-1.399668 (0.15601) [-8.97163]</td>
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<tr>
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</table>

### Error Correction:

<table>
<thead>
<tr>
<th></th>
<th>D(LREER)</th>
<th>D(LTOT)</th>
<th>D(LOPEN)</th>
<th>D(LSG2USGDP)</th>
<th>D(LRXP2GDP)</th>
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<tr>
<td>CointEq1</td>
<td>-0.036459 (0.03716) [-0.98106]</td>
<td>-0.007505 (0.02954) [-0.25404]</td>
<td>-0.292922 (0.06287) [-4.65931]</td>
<td>0.053210 (0.03380) [ 1.57421]</td>
<td>-0.064288 (0.09077) [-0.70829]</td>
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<tr>
<td>D(LREER(-1))</td>
<td>0.226749 (0.10519) [ 2.15552]</td>
<td>0.204016 (0.08363) [ 2.43949]</td>
<td>-0.392367 (0.17796) [-2.20481]</td>
<td>-0.016152 (0.09568) [-0.16882]</td>
<td>-0.182786 (0.25693) [-0.71143]</td>
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<tr>
<td>D(LREER(-2))</td>
<td>0.283161 (0.10827) [ 2.61539]</td>
<td>-0.074239 (0.08607) [-0.86251]</td>
<td>-0.296558 (0.18316) [-1.61914]</td>
<td>-0.066266 (0.09847) [-0.67292]</td>
<td>9.04E-06 (0.26443) [ 3.4e-05]</td>
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<tr>
<td>D(LTOT(-1))</td>
<td>-0.313311 (0.14369) [-2.18044]</td>
<td>-0.221740 (0.11424) [-1.94108]</td>
<td>-0.039810 (0.24309) [-0.16377]</td>
<td>0.082939 (0.13069) [ 0.63460]</td>
<td>-0.308476 (0.35095) [-0.87897]</td>
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<tr>
<td>D(LTOT(-2))</td>
<td>-0.293973 (0.13519) [-2.17448]</td>
<td>-0.178087 (0.10748) [-1.65695]</td>
<td>-0.118607 (0.22871) [-0.51860]</td>
<td>-0.246201 (0.12296) [-2.00222]</td>
<td>-0.284341 (0.33019) [-0.86114]</td>
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</table>
## Appendix

<table>
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<tr>
<th>D(LOPEN(-1))</th>
<th>0.109335</th>
<th>0.103819</th>
<th>0.173283</th>
<th>-0.060981</th>
<th>-0.032048</th>
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<td></td>
<td>(0.09712)</td>
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<td>[2.76870]</td>
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<td>0.334317</td>
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<td>[1.46592]</td>
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<td>(0.21634)</td>
<td>(0.11632)</td>
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<td>[0.57097]</td>
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<td>D(LRXP2GDP(-1))</td>
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<td>-0.072959</td>
<td>-0.146192</td>
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<td>-0.024450</td>
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</table>

| R-squared           | 0.287384 | 0.175318 | 0.419935 | 0.173746  | 0.088751  |
| Adj. R-squared      | 0.192941 | 0.066023 | 0.343059 | 0.064242  | -0.032017 |
| Sum sq. resid       | 0.025831 | 0.016326 | 0.073928 | 0.021370  | 0.154093  |
| S.E. equation       | 0.017642 | 0.014025 | 0.029844 | 0.016046  | 0.043088  |
| F-statistic         | 3.042933 | 1.604076 | 5.462490 | 1.586669  | 0.734887  |
| Log likelihood      | 255.1776 | 276.9711 | 205.2138 | 264.1840  | 170.3446  |
| Akaike AIC          | -5.119529| -5.578340| -4.068038| -5.309137 | -3.333570 |
| Schwarz SC          | -4.796344| -5.255745| -3.745443| -4.986542 | -3.01975  |
| Mean dependent      | -0.002582| -0.004974| 0.007251 | 0.005344  | 0.010185  |
| S.D. dependent      | 0.019637 | 0.014512 | 0.036821 | 0.016588  | 0.042414  |

| Determinant resid covariance (dof adj.) | 1.44E-17 |
| Determinant resid covariance | 7.33E-18 |
| Log likelihood | 1200.100 |
| Akaike information criterion | -23.89685 |
| Schwarz criterion | -22.14946 |
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