Exchange-Rate Systems and Interest-Rate Behaviour: The Experience of Hong Kong and Singapore

Y K Tse
Paul S L Yip

July 2002
Exchange-Rate Systems and Interest-Rate Behaviour: 
The Experience of Hong Kong and Singapore

Y.K. Tse
School of Economics and Social Sciences
Singapore Management University
469 Bukit Timah Road, Singapore 259756
E-mail: yktse@smu.edu.sg, Fax: (65) 6822-0833, Telephone: (65) 6822-0257

and

Paul S.L. Yip
Nanyang Business School
Nanyang Technological University
Nanyang Avenue, Singapore 639798
E-mail: aslyip@ntu.edu.sg, Fax: (65) 6791-3697, Telephone: (65) 6790-4983

July 2002

Abstract: In this paper we consider the implications of the two different exchange-rate systems in Hong Kong (HK) and Singapore (SP) on the economic performance of these two economies. While HK has a pegged exchange-rate regime under a currency board system (CBS), SP has a managed-float system with monitoring band. We examine whether the managed-float system of SP provides an advantage over the rigid CBS of HK in mitigating the recession caused by the Asian Financial Crisis (AFC), and the implications of the differences in the exchange-rate systems on interest-rate behaviour. Our empirical results show that the monitoring band system in SP has not only allowed a greater flexibility in the choice of the exchange rate, but also a greater autonomy in the choice of interest rate to mitigate the crisis, recession or overheating.

JEL Classification: E42, E58

Acknowledgment: Y.K. Tse acknowledges research support from the Wharton-SMU Research Center.
1 Introduction

Hong Kong (HK) and Singapore (SP) are two Asian economies with many similarities. Both economies are small and open (in terms of trade and capital flows), with relatively well developed financial sectors. They have, however, rather different monetary systems and exchange regimes. HK has a currency board system (CBS) under which the HK dollar is pegged to the US dollar at a fixed exchange rate. On the other hand, SP has evolved from a classical sterling-based CBS into a managed-float system under which the value of the SP dollar is managed against an undisclosed trade-weighted basket of foreign currencies. In this paper we consider the implications of the two exchange-rate systems on the economic performance of the two economies. In particular, we examine whether the managed-float system of SP provides an advantage over the rigid CBS of HK in mitigating the recession caused by the Asian Financial Crisis (AFC), and the implications of the differences in the exchange-rate systems on interest-rate management.

Among the economies with a CBS, HK is probably the one with the most developed financial sector and the highest capital mobility\(^1\). As pointed out by Kwan and Lui (1996), the economic health of the HK economy has made HK’s modern CBS an important benchmark for international comparisons, evaluations and theoretical developments of the CBS.\(^2\) The recent paper by Tse and Yip (2002) provides a detailed account of the currency board reforms in HK and their impacts on the interbank market. As pointed out by Tsang (1999) and Yip (1999), the substantial surge in HK’s interest rate during the crisis period was the main cause of the subsequent plunge in asset price and recession, and hence the source of economic pains. Yip and Wang (2002) argued that the prolonged deflation and the severe recession in HK subsequent to the AFC was due to

---

\(^1\)See Tse and Yip (2002) for further details.

\(^2\)Kwan and Lui (1996) noted that “the economic health and significant strength of Hong Kong provide an ideal situation to test the vulnerability of a currency board system when it is confronted with a crisis. ... if Hong Kong’s currency board has to face a crisis when it is subject to shocks of specified magnitude, then it is hard to imagine that the currency board in a country with poorer economic health can survive under the same scenario.”
the inflexibility of HK’s exchange-rate system on one hand and the inflexibility of prices and wages on another.

While comments on the role of HK’s CBS in helping the economy to counter the crisis and post-crisis recession are generally unfavourable, SP’s exchange-rate policy is, however, generally commendable. Lu and Yu (1999) believed that “Singapore’s ... credible managed floating regime offers a lesson worthy of attention from Hong Kong” and that “the inherent rigidity of the [currency board] system has ... cost Hong Kong heavily, by causing procyclical volatility of real interest rates and prices”. Yip and Wang (2001) and Rajan and Siregar (2002) noted that the SP government allowed the SP dollar to depreciate by about 20% vis-à-vis the US dollar during the crisis and post-crisis periods, which succeeded in offsetting the adverse impact of a permanent realignment of the US dollar vis-à-vis other Asian currencies. Thus, the relative successful experience of SP in dealing with the crisis and the post-crisis recession is worth special attention and consideration by other small open economies, including HK.

As pointed out by Rajan (2002) and Corrado et al. (2002), SP’s exchange-rate system is an ideal example of the “monitoring band” system favoured by Williamson (2000). According to Williamson, both the monitoring band and the “crawling band” are exchange-rate “band[s] around a parity that [are] periodically adjusted in relatively small steps in a way intended to keep the band[s] in line with the fundamentals.” Compared with the fixed exchange-rate system or Krugman’s (1991) type of target zone, the adjustable band systems have the advantage of minimizing the possibility of a collapse or disruptive change in the domestic exchange rate arising from prolonged differences between the home and foreign countries’ fundamentals. In addition, as we shall explain in section 2, the adjustable band systems have the advantage of allowing certain degree of independence in the domestic interest-rate (monetary) policy even for an economy as small and open as SP. On the other hand, a monitoring band, as opposed to a crawling band,
“does not involve an obligation to defend the edge of the band. The obligation is instead to avoid intervening within the band (except in a tactical way, to prevent unwarranted volatility) ... the authorities ... have a whole extra degree of flexibility ... if they decide the market pressures are overwhelming, they can choose to allow the rate to take the strain even if this involves the rate going outside the band.” - Williamson (2000), p.292.

Williamson also elaborated that the monitoring band system is different from, and has obvious advantages over, a floating regime:

“[H]aving a monitoring band may make a difference even if the authorities choose not to intervene, so long the market knows that they can employ policy weapons which they might wield at some future date in seeking to push the rate back within the band, and they know where the band is. This knowledge should make the market fearful of pushing the rate so far as to set up the conditions for a bear squeeze (or a “bull squeeze”). Another possible reason is that the market may believe that the authorities have chosen a correct estimate of the long-run equilibrium rate in their positioning of the band, and this again may discourage the market from pushing the rate as far as it would otherwise go.”- Williamson (2000), p.292.

After explaining that “if a country intends to pursue a fixed exchange rate policy, then it ought to do it properly by employing a currency board”, Williamson went on to suggest that “the debate on exchange rate policy ought not to concern fixed versus floating rates, but rather currency boards versus crawling (monitoring) bands.” These comments provide a strong motivation for a study on the exchange-rate systems of HK and SP, which is important for the debate on the choice of an exchange-rate system.

There are some recent empirical studies on the exchange-rate systems in HK and SP. Lu and Yu (1999), Yip and Wang (2001) and Yip (2002) showed that the ability
of SP to use exchange-rate depreciation to absorb and mitigate the impact of the crisis helped SP tide over the crisis and post-crisis periods with less economic pain. Tse and Yip (2002) studied the effects of the reforms in the CBS in HK on the interest-rate differential between HK and US. They found that the AFC caused a rise in the level and volatility of the interest-rate differential during the crisis. They also found that the introduction of the anti-crisis package and the eventual fading out of the AFC brought both the level and volatility of the HK-US interest differential back to the pre-crisis level. However, there are no similar studies on the SP-US interest differential, thus forbidding a comparison of the interest-rate behaviour under the two exchange-rate systems during the pre-crisis, crisis and post-crisis periods. In this paper, we shall fill this empirical gap.

The main objectives of this paper are as follows. First, we investigate whether the monitoring band system in SP is associated with a greater independence of the interest-rate policy in SP. If so, this could be an advantage over the rigid CBS, as exemplified by the choice of lower interest rate as well as lower exchange rate in SP to mitigate the post-crisis recession (see further discussions in section 2). Second, we examine whether the monitoring band system in SP, as compared against the CBS in HK, is associated with a lower volatility of the domestic interest rate relative to the US during the pre-crisis, crisis and post-crisis periods. Third, we investigate whether the differences in the exchange-rate systems are associated with a higher domestic-US interest premium in HK during the crisis. If the empirical findings for the last two questions are positive, it would imply additional advantages of SP’s monitoring band system over HK’s CBS. Fourth, we provide improvement over Tse and Yip’s (2002) empirical analysis. In this paper, we allow for a difference in the interest-rate response between the crisis and the non-crisis periods, thus enabling us to investigate whether there is any panic response in the two interbank markets during the crisis period. As we shall see, allowing for a difference in the interest-rate response results in higher estimates of the HK-US interest
differential during the AFC.

The arrangement of this paper is as follows. In section 2, we discuss the exchange-rate systems in the two economies, with special emphasis on their implications for interest-rate movements and policies. We point out that the SP government has a very powerful set-up to influence the equilibrium exchange rate. The powerful set-up is the underlying reason for the credibility of SP’s exchange-rate system. Subsequently, we outline the hypotheses to be tested. The data and the econometric methodology are described in section 3. We report the empirical results in section 4. Finally, section 5 provides the conclusion.

2 The Exchange-Rate Systems in HK and SP: Some Testable Hypotheses

2.1 The Currency Board System in HK

Since October 1983, HK has adopted the CBS in which the money supply is fully backed up by the US dollar held at the Exchange Fund of the Currency Board, and the HK dollar is effectively fixed at the official rate of US$1 to HK$7.80. Because of the high capital mobility and the fixed exchange-rate system, uncovered interest arbitrage will ensure that HK’s interest rate will follow the US interest rate fairly closely during normal periods. In other words, with the high capital mobility and the CBS, HK has no (or at most very little) independence in the choice of her domestic interest rate. Thus, whether there is overheating (such as the asset-bubble period between 1991 and mid 1997) or recession (such as the post-crisis recession between late 1998 and 2002) in the domestic economy, HK still has to adopt an interest-rate level similar to that in the US, even if this level is out of line with the level desirable to HK.

3 Under the system, any one of the three note-issuing banks wishing to print HK dollar notes need to surrender an equivalent amount of US dollar (at the official rate) to the Exchange Fund in exchange for a Certificate of Indebtedness (CI), which entitles the note-issuing bank to print that amount of HK dollar. On the other hand, the note-issuing banks can always use their holdings of CIs and HK dollar notes to redeem an equivalent amount of US dollar from the Exchange Fund.
As noted by Yip (1999), the outbreak of the AFC weakened the market’s confidence in the continuation of the peg. This, together with a loophole in the CBS, implies a substantial exchange-rate risk for the banks to conduct uncovered interest arbitrage. As a result, banks refrained from performing arbitrage, despite the emergence of a huge interest differential between the HK and US interest rates during the crisis period.

The above discussion suggests several hypotheses for further investigation. First, during the non-crisis period, the absence of an independent interest-rate (monetary) policy in HK results in (a) a small range that the HK-US interest differential can fluctuate, and (b) a strong correlation between the changes in the HK and US interest rates. Second, during the crisis period we may expect (a) the range of the HK-US interest differential to widen (although this does not imply a greater independence in HK’s interest-rate policy), and (b) a substantial decline in the correlation between the changes in the HK and US interest rates.

Tse and Yip (2002) provided some empirical evidence related to the above hypotheses. They found that the AFC did cause a surge in the level as well as the volatility of the HK-US differential of the three-month interbank rates. There are, however, some limitations in their empirical results. First, the average surge in the differential of the interbank rate (1.28%) appears to be too small. Second, in their GARCH model they do not allow for a possible difference in the dynamic response of the interest-rate differential during the crisis and non-crisis periods. In this paper, we allow the dynamic response (as determined by the AR coefficients) to differ in the crisis and non-crisis periods. As we shall see in section 4, by allowing a difference in the AR coefficients, we find evidence of panic response in HK’s interbank market during the crisis. In addition, the estimated surge in the interest-rate level during the crisis is larger than that reported by Tse and Yip (2002).

A detailed account of the CBS reforms in HK was documented in Tse and Yip

---

4See section 3 for the details.
(2002). The partition of the various subperiods of HK’s CBS reforms, together with the definition of the AFC period, will be described in section 3. Hereby, we summarize briefly the empirical findings of Tse and Yip (2002). These findings will be revisited again in section 4 to compare against the new empirical results.

(a) The loophole in HK’s CBS allowed the Hong Kong and Shanghai Banking Corporation (HSBC) to create money without a parallel increase in the US dollar holding as the foreign exchange backup.\(^5\) This caused a fairly substantial downward bias in HK’s three-month rate before the monetary reform introduced in 1 July 1988.

(b) The first monetary reform (Accounting Arrangements) introduced on 1 July 1998 removed the above loophole and hence the downward bias, leaving the HK three-month rate a moderate risk/liquidity premium (of 32.7 basis points) relative to the US rate.

(c) The second reform (the introduction of the Liquidity Adjustment Facility (LAF) on 1 June 1992) reduced the three-month rate premium (to 14 basis points).

(d) The misguided reform (revised mode of monetary operation) introduced on 16 March 1994 did not only remove the above premium but also led to a (slight) downward bias (of 9.9 basis points).

(e) With the revitalization of interest arbitrage arising from the convertibility undertaking measure in the anti-crisis package and the eventual fading out of the crisis, the HK three-month rate was on par with the US rate during the post-crisis period.

2.2 The Monitoring Band System in SP

Unlike HK, SP has opted for an exchange-rate targeting system. The Monetary Authority of Singapore (MAS) is equipped with a powerful set-up to target the exchange rate level it desires. The power of the set-up comes from the liquidity drain through the Central Provident Fund (CPF) and the persistent budget surplus. SP has adopted the CPF

\(^5\)Before the first reform in July 1988, the HSBC was the only commercial bank in charge of the interbank clearing system. As explained by Tse and Yip (2002), this special role endowed the HSBC some freedom in creating money supply without a parallel increase in its US dollar holding.
system in which employees and employers are required to contribute a total of 36-40% of the employees’ basic salary into the fund.\(^6\) This, together with the persistent budget surplus, has caused a severe liquidity drain from the economy to the government sector.\(^7\)

To avoid economic transactions being constrained by the liquidity drain, the MAS would re-inject liquidity back into the economy by purchasing US dollar (and selling SP dollar) in the foreign exchange market. By doing so, the MAS achieves the dual objectives of accumulating foreign reserves for the government and re-injecting liquidity back into the economy. An important point of this arrangement is that, with the substantial size of the liquidity drain, the MAS can achieve a wide range of appreciation and depreciation by varying the amount of liquidity re-injection.

There are two main characteristics of SP’s exchange-rate policy since 1980. First, there is some flexibility in the choice of the exchange-rate target, as reflected by the following mix of strategies (see Yip and Wang (2001)):

(a) During the normal period, the MAS targeted an undisclosed but gradually appreciating band of SP’s nominal effective exchange rate (NEER) with a mean appreciation of 2-3% per annum, which in turn reduced SP’s inflation in the long-run through lower imported inflation.

(b) In case of a recession or a crisis, the MAS opted for a slower appreciation or even allowed a major depreciation (by revising the mean and the width of the band) to mitigate the adverse impact on SP’s economy.

Second, as noted by Rajan and Siregar (2002), the MAS in general (except for tactical reasons) refrains from intervening so long as SP’s NEER lies within the (undisclosed and adjustable) target band. In case there are clear evidence that a substantial depreciation

---

\(^6\)Before the AFC, both employers and employees in SP were required to contribute 20% of the employees’ basic salary to the CPF. During the AFC, the SP government reduced the employers’ contribution rate to 10% as part of the package to mitigate the adverse impact of the crisis. With the economy recovering, the rate was revised to 12% and then 16%.

\(^7\)There are withdrawals due to the house- and share-purchasing schemes (in which people can use their CPF money to purchase houses and shares), retirement and other miscellaneous withdrawals. Nevertheless, the net contribution remains substantially high.
is necessary, the MAS revises the parity and/or widens the band so as to let the market force determine the appropriate level and range of the exchange rate.

In the last two decades the SP dollar has been appreciating with only two episodes of major depreciation. The first one was during the recession in 1985/86 and the second one was during the AFC in 1997/98. Nevertheless, there were numerous occasions in which the MAS opted for a higher or lower than average appreciation. For example, during the overheated period of 1991-94 in which there were strong domestically generated inflation arising from the building up of asset bubbles, the MAS opted for a higher than usual appreciation rate of 4-5%. On the other hand, during the slowdown of the US economy in 2001, the MAS opted for a neutral stance on the SP dollar.

Thus, the exchange-rate targeting in SP is less rigid than the exchange-rate peg in HK. Even during the normal period, there was some flexibility in the choice of exchange-rate in SP to cater for the domestic needs of the economy. This flexibility in turn allows SP more independence in its interest-rate (monetary) policy. If the economy is overheated, the MAS may opt for a greater appreciation of the SP dollar by re-injecting less liquidity into the economy. The reduction in money supply will in turn bid up the domestic interest rate and further help cool the overheated economy. On the other hand, if the economy is slowing down, the MAS may opt for a lower, or even zero, appreciation by re-injecting more liquidity back into the economy. This will in turn bring down the domestic interest rate and further help stimulate the slowing economy. As a result, we hypothesize that the greater flexibility in SP’s exchange-rate target implies more independence in its interest-rate policy, which in turn implies (a) the range of the SP-US interest differential should be bigger than the range of the HK-US interest differential.

---

8 As there was already downward pressure on the SP dollar during the recession and the crisis, the SP government did not achieve depreciation through intervention. Instead, it simply widened the band to allow the market force to push the SP dollar to lower levels. Nevertheless, it does not mean that the SP government did not play an important role in this process. For example, at the beginning of the AFC, the market was still hesitating whether the SP government would intervene. After deciding that it would be better to let the SP dollar depreciate, the Finance Minister announced his intention to let the market force determine the value of the SP dollar, giving the market the greenlight to push the SP dollar further down.
differential, and (b) the correlation between the changes in the SP and US interest rates should be lower than that between HK and the US.

Having noted the implications of the first characteristic, we now come to the implications of the second characteristic: the MAS usually refrains from intervention as long as SP’s NEER lies within the target band. Compared with the case of a rigid peg, this implies that SP has an extra variable (exchange rate) to absorb the impact of any exogenous shocks. This would in turn mitigate the burden of the domestic interest rate as an adjusting variable and hence reduce the volatility of SP’s interest rate. For example, consider the case of an exogenous capital inflow (outflow). Without any change in SP’s exchange rate, the exogenous capital inflow (outflow) will cause a decline (increase) in the SP interest rate. However, with the SP dollar being allowed to fluctuate within the band, the capital inflow (outflow) will cause an appreciation (depreciation) of the SP dollar. This would in turn mitigate the capital flow and hence induce a smaller rise (fall) in the SP interest rate. This case is particularly obvious during the AFC in which the speculative pressure on the Asian currencies spilled over to SP and exerted an upward pressure on the SP interest rate. By widening the target band and announcing the intention to let the market force determine (i.e., depreciate) the value of the SP dollar, the SP government allowed the SP dollar to fall to a lower level, which in turn mitigated the upward pressure on SP’s interest rate. Thus, compared with the case of a rigid peg/targeting, the second characteristic of allowing the SP dollar to fluctuate within a band implies a lower volatility in the SP interest rate.

Before summarizing the hypotheses to be tested, we would like to highlight that the hypothesis of a lower volatility of SP’s interest rate does not contradict with the hypothesis of a larger range of interest rate that SP can choose. The former is due to the existence of a band within which the SP dollar is free to fluctuate, while the latter is related to the greater flexibility in revising the target of the SP dollar according to the prevailing domestic economic conditions. As we shall see, the two seemingly
alike measures are in fact captured by two different sets of parameters in our empirical model. In fact, we believe that the MAS has so far managed to strike an excellent balance between the two characteristics.

2.3 Hypotheses to be tested

Summarizing the discussions in the above subsections, we arrive at the following testable hypotheses:

(1) During the non-crisis period, the expected appreciation of the SP dollar implies that the average SP-US interest differential should be at a discount.

(2) During the non-crisis period, the greater independence of interest-rate policy in SP implies that (a) the range of the SP-US interest differential should be wider than the range of the HK-US interest differential, and (b) the correlation between the changes in the HK and the US interest rates should be higher than that between SP and the US.

(3) The monitoring band system in SP implies that there is an extra variable (exchange rate) to absorb the impact of exogenous shocks. This is, however, not the case for HK’s CBS. Thus, we expect the volatility of the SP-US differential to be lower than that of the HK-US differential during both the crisis and non-crisis periods.

(4) The crisis will lead to (a) a surge in both the HK-US and SP-US interest differentials. This would also mean (b) a breakdown of the HK-US and SP-US interest links (i.e., a substantial reduction in the correlation between the changes in the HK and the US interest rates as well as the correlation between the changes in the SP and US interest rates). As there was a substantial discount in the SP-US differential but no (or limited) discount in the HK-US differential before the crisis, there will be (c) a substantial premium in the HK-US differential during the crisis period. The SP-US differential, however, could be positive, zero or negative.

(5) The changes highlighted in (4) will be reversed during the post-crisis period.
3 The Data and the Methodology

Our data consist of daily observations of the HK, SP and US three-month interbank rates. The data were obtained from the Datastream, and cover the period 1 April 1986 through 28 February 2002, with 4153 observations in total.\(^9\)

Figure 1 plots the three-month interbank rates of the three economies, and figure 2 presents the three-month interest-rate differentials of HK-US and SP-US. Table 1 provides some summary statistics of the data, as well as the tests for unit root using the Augmented Dickey-Fuller (ADF) test. The ADF statistics show that the hypothesis that the SP and US interbank interest rates are nonstationary cannot be rejected at the 10 percent level, while the hypothesis that the HK interbank interest rates are nonstationary cannot be rejected at the 5 percent level.\(^10\) In contrast, the hypotheses that the differenced interest rates are nonstationary are rejected at the 1 percent level for all economies. Thus, the results indicate that all interbank interest rate series contain a unit root. Next we check the stationarity of the HK-US and SP-US interest-rate differentials. The ADF of the HK-US and SP-US interest-rate differentials are, respectively, \(-6.081\) and \(-3.727\). Thus, the evidence is in support of the interest-rate differentials being stationary. Furthermore, in the system of three interest rates Johansen’s trace statistics for the null hypotheses of at most one cointegrating equation and at most two cointegrating equations are, respectively, 17.137 and 0.037, providing additional evidence for two cointegrating equations.

As documented in Tse and Yip (2002), the CBS in HK went through several reforms in the last two decades. Also, the AFC was an external shock that had significant impact on the economy. To capture the possible structural breaks in the data due to the CBS reforms and the AFC we divide the sample period into seven subperiods, which are

\(^9\)Although the CBS in HK came into effect in October 1983, the data we collected from Datastream were only available from 1986.

\(^{10}\)The results of these tests are based on the critical values given by MacKinnon (1991).
summarized as follows:11

<table>
<thead>
<tr>
<th>Subperiods (No. of obs.)</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>P(_1): 86/4/1 – 88/6/30 (588)</td>
<td>No monetary reform</td>
</tr>
<tr>
<td>P(_2): 88/7/1 – 92/5/31 (1021)</td>
<td>Accounting Arrangements</td>
</tr>
<tr>
<td>P(_3): 92/6/1 – 94/3/15 (467)</td>
<td>Liquidity Adjustment Facility</td>
</tr>
<tr>
<td>P(_4): 94/3/16 – 97/10/22 (941)</td>
<td>Revised Mode of Operations, without AFC</td>
</tr>
<tr>
<td>P(_5): 97/10/23 – 98/9/04 (227)</td>
<td>Revised Mode of Operations, with AFC</td>
</tr>
<tr>
<td>P(_6): 98/9/5 – 98/12/18 (75)</td>
<td>Technical Measures, with AFC</td>
</tr>
<tr>
<td>P(_7): 98/12/19 – 02/2/28 (834)</td>
<td>Technical Measures, without AFC</td>
</tr>
</tbody>
</table>

For the SP data, the only major external shock is the AFC. To capture the possible structural break in the data we partition the sample period into three subperiods of crisis and non-crisis as follows: (a) P\(_1\): 86/4/1 – 97/10/22 (pre-crisis), (b) P\(_2\): 97/10/23 – 98/10/9 (crisis), and (c) P\(_3\): 98/10/10 – 02/2/28 (post-crisis).12

As in Tse and Yip (2002), the interest-rate differentials of HK/SP versus US are modelled using a model with time-varying conditional mean and conditional variance. We denote the HK/SP three-month interbank rate at time \(t\) by \(r_t\) and the three-month US interbank rate by \(r_{Ut}\).13 Let \(y_t = r_t - r_{Ut}\) denote the interest-rate differential of HK/SP versus US. As \(r_t\) and \(r_{Ut}\) are found to be nonstationary while \(y_t\) is found to

---

11 See Tse and Yip (2002) for the detailed descriptions of the reforms as well as for the justification for the partition of the AFC. The AFC for HK is taken to begin on 97/10/23 and end on 98/12/18. While the starting date of the AFC is fairly noncontroversial, choices of the ending data are open. First, a possible (international) choice is 98/10/9 when the hedge funds, being forced to unwind their speculative position due to banks’ credit tightening and redemption pressure arising from the Long Term Capital Management crisis, stopped financing their speculative leverage through Yen borrowings. Because of the latter, the US$ fell sharply against the Yen within two days: from 130.7 Yen on 7 October to 111.8 Yen on 9 October. Second, a possible (domestic) choice is 98/12/18 when the Hong Kong Association of Bank (HKAB) reduced its deposit rate, not because of any reduction in the US interest rate but because the HKAB perceived the panics in HK were over. As Tse and Yip (2002) have adopted the second choice and found the results to be satisfactory, we will follow this choice for the case of HK in this paper. Note also that the AFC covers the subperiods P\(_5\) and P\(_6\), which are distinguished separately due to the implementation of the Technical Measures during the AFC.

12 As the ending date of the crisis in SP is more related to the international events instead of the domestic events of HK, we have chosen 98/10/9 (the international choice in the previous footnote) as the ending date of the crisis in SP.

13 To economize the use of notations \(r_t\) is used generically for both HK and SP interest rates. This convention is preserved below.
be stationary (see the discussions above), we model the dynamics of the interest-rate differential $y_t$ using an autoregressive process.\footnote{For simplicity in estimation we use autoregressive process to model the stationary series $y_t$.} Furthermore, we allow the volatility of the interest-rate differentials to be time-varying. In addition, dummy variables are introduced in the conditional-mean and conditional-variance equations to capture the effects of the reforms (for HK) and the AFC (for both HK and SP). For example, for the HK-US interest differential, we define $D_t, i = 1, ..., 7$, as a dummy variable such that $D_t = 1$ if $t$ belongs to the subperiod $P_i$, and zero otherwise. Thus, the conditional-mean equation for the interest-rate differential is given by

$$y_t = \sum_{i=1}^{M} \delta_i D_t + \sum_{j=1}^{p} \phi_j y_{t-j} + \varepsilon_t$$  \hspace{1cm} (1)$$

so that $y_t$ follows an autoregressive (AR) process of order $p$. The time-varying intercept $\delta_i$ determines the average interest-rate differential in each subperiod. For the HK-US differential, $M = 7$; for the SP-US differential, $M = 3$.

In equation (1) the speed of adjustment of the interest-rate differential is determined by the AR coefficients $\phi_j$. This model was used by Tse and Yip (2002) for the HK data, with the assumption that the adjustment process is the same during and outside the AFC. In this paper, we relax this restriction in the empirical model and allow $\phi_j$ to vary in the crisis and non-crisis subperiods. This extension will be applied to the SP data as well. Further details will be given in section 4.

We assume the conditional-variance of the residual $\varepsilon_t$ follows a generalized autoregressive conditional heteroscedasticity (GARCH) process. The GARCH model was first suggested by Bollerslev (1986) following the earlier work of Engle (1982), and has since been applied extensively in the empirical finance literature.\footnote{See, for example, Bollerslev, Chou and Kroner (1992) for a survey.} Thus, by assumption $\varepsilon_t \mid \Phi_{t-1} \sim N(0, \sigma_t^2)$, such that conditional on the information set $\Phi_{t-1}$ at time $t-1$ the residual $\varepsilon_t$ is distributed as a normal variable with mean zero and variance $\sigma_t^2$. In particular,
we assume a GARCH(1, 1) model such that
\[
\sigma_t^2 = \sum_{i=1}^{M} \gamma_i D_i + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2.
\]

In this equation the conditional-variance is allowed to shift according to the subperiod. The parameter \(\gamma_i\) determines the shift in the volatility of the interest-rate differential in subperiod \(P_i\).\(^{16}\)

We estimate the parameters of the conditional-mean and conditional-variance equations jointly using the quasi-MLE (QMLE) method (see Bollerslev and Wooldridge, 1992), and adopt a general-to-specific approach by testing the restrictions on the dummy variables, which are tests of the impact of the reforms and the AFC as well as the equality of the AR coefficients over different subperiods. Restrictions on model parameters are tested using the likelihood ratio (LR) statistic. LR is distributed approximately as a \(\chi^2_R\) when the restrictions are valid, where \(R\) denotes the number of restrictions on the parameters.

To examine the comovements of the changes of the HK/SP interest rates versus the US, we consider a bivariate model. The conditional-mean structures are again assumed to follow autoregressive schemes. We denote the residuals of \(\Delta r_t = r_t - r_{t-1}\) and \(\Delta r_{U,t} = r_{U,t} - r_{U,t-1}\) by \(\xi_{1t}\) and \(\xi_{2t}\), respectively, and let \(\xi_t = (\xi_{1t}, \xi_{2t})'\). The following AR processes are assumed
\[
\Delta r_t = \delta_r + \sum_{j=1}^{p_r} \phi_{rj} \Delta r_{t-j} + \xi_{1t},
\]
\[
\Delta r_{U,t} = \delta_{U} + \sum_{j=1}^{p_U} \phi_{Uj} \Delta r_{U,t-j} + \xi_{2t},
\]
so that \(\Delta r_t\) is an AR\((p_r)\) process and \(\Delta r_{U,t}\) is an AR\((p_U)\) process.\(^{17}\)

\(^{16}\)Note that we could allow the persistence of the volatility (as determined by \(\alpha\) and \(\beta\)) to vary in the crisis and non-crisis subperiods. However, we believe this extension is of second order. Furthermore, the software used for computation does not allow for this extension.

\(^{17}\)As we are not considering interest differentials, dummy variables are not incorporated into the model. Thus, daily interest-rate changes are assumed to follow the same process regardless of CBS reforms and/or AFC.
For the conditional-variance process, we adopt a multivariate GARCH model in which $\xi_t | \Phi_{t-1} \sim N(0, \Omega_t)$. The conditional-variance matrix is assumed to follow the BEKK(1,1) structure given by\(^{18}\)

$$
\Omega_t = \begin{pmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{pmatrix} \begin{pmatrix} c_{11} & c_{12} \\ 0 & c_{22} \end{pmatrix} + \left( \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix} \right) \Omega_{t-1} \left( \begin{pmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{pmatrix} \right) + \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix} \xi_{t-1} \xi_{t-1} \begin{pmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{pmatrix}.
$$

\(^{(2)}\)

For the conditional-variance of $\Delta r_t$ (for HK or SP), dummy variables are added to allow for shifts (increases) in the volatility during the AFC. These dummy variables are added to the diagonal elements of the first term (the product of the triangular matrices) on the right hand side of equation (2) above. The estimated equations are used to compute the (daily) conditional correlations over the whole sample period, from which the average correlations over the subperiods of pre-crisis, crisis and post-crisis are calculated.

4 The Empirical Results

4.1 Univariate Models

The estimation results of the univariate GARCH models of the interest-rate differential of HK-US and SP-US are summarized in tables 2 and 3, respectively. Model 1 in table 2 is a replication of the estimation results in Tse and Yip (2002), with the time span of the data expanded. As explained in section 2, Model 1 does not allow for a difference in the interest-rate response (i.e., the AR coefficients) during the crisis and non-crisis periods. In contrast, the AR coefficients in Model 2 allow for differential response in the following periods: (a) the non-crisis (NC) period prior to and after the AFC, (b) the crisis period prior to the anti-crisis package (C1), and (c) the crisis period after the anti-crisis package (C2). Using the penalized likelihood approach as given by the Aikaike Information Criterion (AIC), Model 2 is preferred to Model 1 for the HK-US

\(^{18}\)The BEKK model is named after Baba, Engle, Kraft and Kroner (see Engle and Kroner (1985)). It has the advantage of ensuring the conditional-variance matrix to be theoretically positive semi-definite. This model has been widely used in the financial econometrics literature.
differentials.\textsuperscript{19} Similarly, in table 3 Model 2 allows the AR coefficients to vary in the crisis (C) and non-crisis (NC) subperiods.\textsuperscript{20} Based on the AIC, Model 2 is preferred to Model 1.

By allowing the AR scheme to differ during the crisis, we are in a position to investigate whether there is any evidence of panic response in the interbank markets. From Model 2 in table 2, we note that $\hat{\phi}_1^C = 1.17$, providing evidence that there was a panic response in the HK interbank market during subperiod P$_5$ (i.e., the crisis period before the anti-crisis package). The estimate implies that there was not only a tendency for the impact of the shock to persist, but also a tendency for the differential to widen the next day. However, the estimate $\hat{\phi}_2^C = -0.24$ suggests that the impact of the shock would start to narrow down from the second day. With the imposition of the convertibility undertaking measure within the anti-crisis package, $\hat{\phi}_1^C$ is no longer greater than 1, confirming our belief that the revitalisation of interest arbitrage has removed the panic interest-rate response. As SP allowed substantial depreciation of its currency vis-à-vis the US dollar to absorb the shocks during the crisis period, the estimate $\hat{\phi}_1^C = 0.86$ in table 3 confirms that there was no panic element in SP’s interest-rate response. It is noted that the sum of $\hat{\phi}_i$ (for both the HK and SP equations) during the crisis period are less than that of the non-crisis period, reflecting the fact that the shocks during the crisis are temporary in nature.

We now consider the estimated conditional-variance equations for the HK market. A comparison of Model 1 and Model 2 suggests that the $\hat{\delta}_i$ are very close to each other during the pre-crisis and post-crisis periods (i.e., subperiods P$_1$, P$_2$, P$_3$, P$_4$ and P$_7$). Thus, Model 2 confirms the following empirical findings in Tse and Yip (2002):

(a) The loophole in HK’s CBS that allowed the HSBC to create money without a parallel increase in the US dollar holding as the foreign exchange backup caused a fairly

\textsuperscript{19}Specifically, we select the model to minimize $-2 \times \log \text{likelihood} + 2 \times \text{number of parameters}$. The likelihood ratio test is not used here as the two models are not nested.

\textsuperscript{20}Unlike the case of HK, there is no further breakdown in the crisis period.
substantial downward bias in HK’s three-month rate (of about 98.6 + 35.3 = 133.9 basis points) in subperiod $P_1$.

(b) The monetary reform (Accounting Arrangements) introduced at the beginning of subperiod $P_2$ removed the above loophole and hence the downward bias, leaving the HK three-month rate a risk/liquidity premium of 35.3 basis points relative to the US rate.

(c) The introduction of HK’s version of discount window (LAF) in the second monetary reform reduced HK’s three-month rate premium to 15.5 basis points.

(d) The misguided reform (revised mode of monetary operation) introduced at the beginning of subperiod $P_4$ did not only remove the above premium but also led to a downward bias of 14.2 basis points in subperiod $P_4$. According to Tse and Yip (2002), this misguided reform of injecting extra liquidity during substantial over-subscription of IPOs fuelled the asset bubbles in this subperiod and represented temporary violations of the monetary rule under the CBS. They also noted that, however, these violations were temporary in nature.

(e) With the revitalization of interest arbitrage arising from the convertibility undertaking measure in the anti-crisis package and the eventual fading out of the crisis, the HK three-month rate was on par with the US rate during the post-crisis period.

Nevertheless, a comparison of $\hat{\delta}_5$ in Model 1 and Model 2 confirms our belief that the failure to take into account the possibility of different interest-rate responses in the crisis and non-crisis periods may have led to a downward bias in the estimated interest differential between HK and the US in subperiod $P_5$. The results in Model 2 show that the estimated average interest differential is 2.01% and the average surge in the differential is 2.15% (i.e., 2.01 + 0.14), larger than the corresponding estimates in Model 1 and in Tse and Yip (2002). In addition, the estimate $\hat{\delta}_6$ suggested that there was a similar downward bias in subperiod $P_6$.

We now compare $\hat{\delta}_i$ and the implied range of the SP and HK interest differentials
during the pre-crisis and post-crisis periods.\textsuperscript{21} During the pre-crisis period, $\hat{\delta}_1$ in Model 2 of table 3 shows that there was a 2.27% discount in the SP-US three-month interest differential arising from the expected appreciation of the SP dollar vis-à-vis the US dollar. Meanwhile, the estimated standard error of $\hat{\delta}_1$ shows that the implied four standard-error range of the SP-US interest differential is 3.31%.\textsuperscript{22} Similarly, $\hat{\delta}_3$ and its estimated standard error suggests that: (a) during the post-crisis period, there was a 2.39% discount in SP’s three-month rate relative to the US rate, reflecting that the market was expecting similar appreciation of the SP dollar vis-à-vis the US dollar, and (b) the implied four standard-error range of the SP-US interest differential is 4.88%. In fact, a test for $H_0 : \delta_1 = \delta_3$ gives a LR statistic of 0.0374, suggesting that there was no change in the SP-US interest discount before and after the crisis. Similarly, the LR statistic of $H_0 : \gamma_1 = \gamma_3$ is 0.4828, suggesting that there was no change in SP’s interest rate volatility between the pre-crisis and post-crisis periods. Imposing these restrictions gives an estimate of 2.32% interest discount and an implied four standard-error range of 3.29% for the non-crisis period. The latter implies that there is a relatively wide range of interest rate that SP can choose during the non-crisis period. On the other hand, due to the fixed exchange rate between the HK dollar and the US dollar, there was no such interest discount in HK during the pre-crisis (i.e., subperiods P\textsubscript{3} and P\textsubscript{4}) and post-crisis (i.e., subperiod P\textsubscript{7}) periods. Besides, the implied four standard-error range of the HK-US interest differential was only 0.24%, 0.21% and 0.23% for subperiods P\textsubscript{3}, P\textsubscript{4} and P\textsubscript{7}, respectively. Such small ranges imply that the HK-US interest-rate differential did not vary much during the non-crisis periods. Thus, we have found some supporting evidence for the argument that: (a) the expected appreciation of the SP dollar vis-à-vis the US dollar led to a SP-US interest discount during the non-crisis period, and (b)

\footnotesize{\textsuperscript{21}The time span for the pre-crisis and the post-crisis periods in HK are different from those of SP (see footnote 12). We have chosen to report the results with the longest time span for each economy. Nevertheless, the results with the same over-lapping time span for the two economies are qualitatively the same.}

\footnotesize{\textsuperscript{22}This is measured by $4 \times \text{standard error of} \hat{\delta}_1 \div (1 - \hat{\phi}_1^{\text{NC}} - \hat{\phi}_3^{\text{NC}})$, which is approximately the 95% interval of the interest-rate differential.}
when compared with HK, greater flexibility of exchange rate in SP allowed the economy more independent choices in its interest-rate policies.

In addition to the results of more independent choices of interest-rate policies in SP, it is also interesting to note that $\hat{\gamma}_i$ in Model 2 of tables 2 and 3 imply that the volatility of SP’s interest rate relative to the US was lower than that of HK during the non-crisis period. As shown in Model 2 of table 3, $\hat{\gamma}_1$ and $\hat{\gamma}_3$ imply that the unconditional standard deviations of SP’s interest rate during the pre-crisis and post-crisis periods are 14.4 basis points and 13.9 basis points, respectively. These are lower than the corresponding figures of 24.9 basis points and 25.3 basis points in HK (i.e., in subperiods $P_4$ and $P_7$), confirming our belief that the possibility of exchange-rate changes in SP during the normal period helped absorb the impact of external shocks on SP’s interest rate.

The outbreak of the AFC caused an increase in SP’s interest rate. In fact, the crisis virtually removed SP’s usual interest rate discount relative to the US, leaving $\hat{\delta}_2$ in Model 2 of table 3 insignificantly different from zero. Yet, the effect of the crisis on SP was much smaller when compared to HK’s 2.15% interest premium relative to the US (i.e., $\hat{\delta}_5$ in Model 2 of table 2).23 One possible reason for the difference was that, during the crisis period, SP allowed a depreciation of the SP dollar vis-à-vis the US dollar so as to absorb some of the shocks and alleviate some of the upward pressure on the SP interest rate. On the other hand, the peg in HK ruled out the use of depreciation (vis-à-vis the US dollar) to absorb the shock. Besides, exchange-rate risk has discouraged arbitrage activities from working to bring the HK interest rate down to the US level. As a result, interest rate in HK has to bear the full burden of the shock. Thus, the flexibility of SP’s exchange rate did not only cause a lower interest premium relative to the US but also a lower volatility. According to Model 2 of tables 2 and 3, the implied unconditional standard deviation of HK’s interest rate was 144.5 basis points, much higher than the 86.4 basis points in SP. With the higher interest rate premium and volatility in HK, it

---

23Chen and Chan (1997), Tsang (1999) and Yip (1999) argued that the high interest rate in HK was the major source of HK’s economic pains during the crisis.
is not surprising for HK to experience a more severe plunge in asset price and economic pains during the crisis.

### 4.2 Bivariate Models

In section 2 we argue that the greater flexibility in the exchange-rate policy in SP has permitted higher autonomy in its interest-rate policy. If SP did use exchange-rate depreciation to absorb external shocks and fine-tune domestic booms and busts, we should observe that, during the non-crisis period, (a) the range of the SP-US interest differential should be wider than that of the HK-US differential, and (b) the correlation between the interest-rate changes in SP and US should be smaller than that between HK and the US. In the univariate estimation, we have seen evidence of the former. We now consider the bivariate estimation to see whether there is evidence for the latter.

Table 4 reports the average correlation coefficients between the changes in interest rate of HK, SP and US during the pre-crisis, crisis, and post-crisis periods. As we can see, the SP-US correlation during the pre-crisis period (0.0684) was smaller than the HK-US correlation (0.1764), thus further supporting our belief that the greater flexibility of exchange rate allowed for a more independent choice of interest-rate policies in SP. During the crisis, the HK-US correlation coefficient plunged to a low level (−0.0044), reflecting a break down in the HK-US interest link arising from speculative attacks and the loophole in the CBS (failure of uncovered interest arbitrage amid the confidence shock). Nevertheless, with the introduction of the convertibility undertaking (anti-crisis package) and the eventual fading out of the crisis, the HK-US interest link is re-established, as reflected in a rebound of the correlation back to the pre-crisis level (0.1553). For SP, the lower correlation during the crisis (0.0090) reflected a breakdown

---

24 As the crisis ended at different dates in HK and SP, we define the pre-crisis, crisis and post-crisis periods, respectively, as: (a) 92/06/01 – 97/10/22, 97/10/23 – 98/09/04, 98/12/19 – 02/02/28 for HK versus US, (b) 86/04/01 – 97/10/22, 97/10/23 – 98/10/09, 98/10/10 – 02/02/28 for SP versus US, and (c) 92/06/01 – 97/10/22, 97/10/23 – 98/09/04, 98/12/19 – 02/02/28 for HK versus SP.

25 It is interesting to note that the HK-US correlation in the post-crisis period is slightly less than that in the pre-crisis period. There are two possible reasons for this: (a) During the earlier part of the
in the SP-US interest link during the crisis period. Nevertheless, the reduction of the correlation in SP was smaller than that in HK, reflecting that the chaos created by the crisis is much smaller in SP. With the fading out of the crisis, the SP-US correlation bounced back to 0.0408.\textsuperscript{26} Despite the above differences between SP and HK, it is interesting to note that the HK-SP correlation (0.1717) remained high during the crisis. One reason is that both economies were subjected to the same contagion crisis among the Asian economies. It is noted that the correlation (0.1938) went up further during the post-crisis period.\textsuperscript{27}

To further examine the relationship between the changes in the US versus the changes in the HK interbank rates in various periods of the HK CBS reforms and AFC, we calculate the average correlation coefficient in each of the seven subperiods partitioned according to the CBS reforms and AFC as described in section 3. The following results are obtained: (a) the average correlation in sub-period $P_1$ is relatively low (0.1261), reflecting the fact that the HSBC’s special position (in creating money supply without a parallel foreign exchange back-up) equipped the HSBC with a moderate autonomy in choosing/fixing the interest rate; (b) the average correlation increased in subperiods $P_2$ and $P_3$ to 0.1848 and 0.1930, respectively. This suggests that the two reforms (namely, the introduction of the Accounting Arrangements and the LAF) succeeded in bringing the HK interest rate more in line with that of the US; (c) the average correlation fell in subperiods $P_4$ to 0.1681, reflecting the downward bias created by the revised mode post-crisis period, there was a severe recession in HK, causing a substantial reduction in the demand for loans in HK. To avoid drastic reduction in loan business, banks in HK were forced to accept lower interest margins (many banks offered new mortgage loans at rates below the prime rate). This might have caused a lower HK-US correlation; (b) During the later part of the post-crisis period, there were a series of interest-rate reductions in the US, bringing the US interest rate to fairly low level. HK’s saving deposit rate would have reached negative level if the HKAB had followed the same amount of rate cut in HK. This resistance of the HKAB to cut interest rates might have caused a lower HK-US correlation.

\textsuperscript{26}Similar to the case of HK-US, the SP-US correlation in the post-crisis period was less than that in the pre-crisis period. This could be due to similar reasons cited for the case of HK, namely, the resistance to follow US in interest-rate reduction.

\textsuperscript{27}As noted in footnotes 25 and 26, both HK and SP resisted further reduction of interest rates during the post-crisis period. This may explain why the HK-SP correlation in the post-crisis period was higher than that in the pre-crisis period.
of monetary operations; (d) after a substantial fall in the average correlation in the crisis (subperiod $P_5$) to $-0.0044$, the average correlation rose to $0.0156$ in sub-period $P_6$, reflecting that the convertibility undertaking did manage to bring the HK interest rate more in line with that of the US. Finally, with the fading out of the crisis (subperiod $P_7$), the average correlation (0.1516) rose back to the pre-crisis level.

5 Conclusions

Williamson (2000) has suggested that the debate on exchange-rate policy should be currency boards versus crawling (monitoring) bands instead of fixed versus floating rates. Along this line, a comparison of the HK and SP exchange rate systems is not only crucial to the two economies, but also important for the debate on the optimal choice of exchange-rate system. In this paper, we consider the potential advantages of one exchange-rate system over the other. Focusing on the linkage between the exchange-rate systems and the interest-rate behaviour in the two economies, we find that the monitoring band system in SP has not only allowed a greater flexibility in the choice of the exchange rate, but also a greater autonomy in the choice of interest rate to mitigate the crisis, recession or overheating. In particular, we find empirical support for the hypothesis that greater flexibility in the exchange rate target in SP was associated with greater independence in its interest rate policy, as reflected by (a) a wider range of SP-US interest differential, and (b) a lower correlation between the changes in the SP and US interest rates. We have also found that MAS’s normal practice of avoiding unnecessary intervention within the monitoring band was associated with a lower volatility in the interest rate in SP during the pre-crisis, crisis and post-crisis periods. On the other hand, there was a higher HK-US interest premium during the crisis. The higher interest premium in HK has been widely believed to be one of the major sources of economic pains in HK.

In this paper we have made some improvement over Tse and Yip’s (2002) empirical
analysis. By allowing a difference in the interest-rate response between the crisis and the non-crisis periods, we find that (a) there is a panic response in HK’s interbank market but not in SP’s, and (b) the estimate of the average HK-US interest premium during the crisis is higher than that reported in Tse and Yip (2002). We also find that the panic response in HK’s interbank market has disappeared with the adoption of the anti-crisis package. On the other hand, both the univariate and bivariate models support Tse and Yip’s (2002) other empirical findings on the impacts of HK’s currency board reforms since the late 1980s. In the bivariate model, we find a breakdown of the HK-US and SP-US interest links during the crisis. After the crisis, the links were somewhat restored. Meanwhile, the correlation between the changes in HK’s and SP’s interest rates rose during the crisis period, reflecting the fact that both were affected by the contagious shocks at that time.
References


Table 1: Summary statistics of three-month interbank rates

<table>
<thead>
<tr>
<th>Statistic</th>
<th>HK</th>
<th>SP</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>6.043</td>
<td>3.607</td>
<td>5.862</td>
</tr>
<tr>
<td>Median</td>
<td>5.875</td>
<td>3.310</td>
<td>5.750</td>
</tr>
<tr>
<td>Maximum</td>
<td>25.188</td>
<td>12.940</td>
<td>10.500</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.625</td>
<td>0.625</td>
<td>1.641</td>
</tr>
<tr>
<td>Std Dev</td>
<td>2.183</td>
<td>1.571</td>
<td>1.750</td>
</tr>
<tr>
<td>Std Skewness</td>
<td>0.798</td>
<td>0.832</td>
<td>0.109</td>
</tr>
<tr>
<td>Std Kurtosis</td>
<td>5.369</td>
<td>3.865</td>
<td>2.820</td>
</tr>
<tr>
<td>ADF statistics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest rates</td>
<td>−2.734</td>
<td>−2.192</td>
<td>−0.160</td>
</tr>
<tr>
<td>Diff. interest rates</td>
<td>−32.122</td>
<td>−30.600</td>
<td>−70.412</td>
</tr>
</tbody>
</table>

Note: ADF statistic is the augmented Dickey-Fuller statistic of test for unit root.
Table 2: Estimation results of the HK-US three-month interest-rate differential

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>s.e.</th>
<th>mean/s.d.</th>
<th>Parameter</th>
<th>Estimate</th>
<th>s.e.</th>
<th>mean/s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi_1$</td>
<td>0.7427***</td>
<td>0.0185</td>
<td></td>
<td>$\phi_1^{NC}$</td>
<td>0.7208***</td>
<td>0.0187</td>
<td></td>
</tr>
<tr>
<td>$\phi_2$</td>
<td>0.0667***</td>
<td>0.0140</td>
<td></td>
<td>$\phi_2^{NC}$</td>
<td>0.0953***</td>
<td>0.0258</td>
<td></td>
</tr>
<tr>
<td>$\phi_3$</td>
<td>0.0666***</td>
<td>0.0140</td>
<td></td>
<td>$\phi_3^{NC}$</td>
<td>0.0777***</td>
<td>0.0224</td>
<td></td>
</tr>
<tr>
<td>$\phi_4$</td>
<td>0.0579***</td>
<td>0.0217</td>
<td></td>
<td>$\phi_4^{NC}$</td>
<td>0.0642***</td>
<td>0.0148</td>
<td></td>
</tr>
<tr>
<td>$\phi_5$</td>
<td>0.0666***</td>
<td>0.0140</td>
<td></td>
<td>$\phi_5^{NC}$</td>
<td>0.1174***</td>
<td>0.0660</td>
<td></td>
</tr>
<tr>
<td>$\phi_6$</td>
<td>0.0666***</td>
<td>0.0140</td>
<td></td>
<td>$\phi_6^{NC}$</td>
<td>-0.2376***</td>
<td>0.0678</td>
<td></td>
</tr>
<tr>
<td>$\phi_7$</td>
<td>0.0666***</td>
<td>0.0140</td>
<td></td>
<td>$\phi_7^{NC}$</td>
<td>0.9179***</td>
<td>0.0342</td>
<td></td>
</tr>
<tr>
<td>$\delta_1$</td>
<td>-0.0454***</td>
<td>0.0074</td>
<td>-0.983</td>
<td>$\delta_1$</td>
<td>-0.0415***</td>
<td>0.0076</td>
<td>-0.986</td>
</tr>
<tr>
<td>$\delta_2$</td>
<td>0.0164***</td>
<td>0.0043</td>
<td>0.354</td>
<td>$\delta_2$</td>
<td>0.0148***</td>
<td>0.0044</td>
<td>0.353</td>
</tr>
<tr>
<td>$\delta_3$</td>
<td>0.0070***</td>
<td>0.0025</td>
<td>0.152</td>
<td>$\delta_3$</td>
<td>0.0065***</td>
<td>0.0025</td>
<td>0.155</td>
</tr>
<tr>
<td>$\delta_4$</td>
<td>-0.0057***</td>
<td>0.0021</td>
<td>-0.124</td>
<td>$\delta_4$</td>
<td>-0.0060***</td>
<td>0.0022</td>
<td>-0.142</td>
</tr>
<tr>
<td>$\delta_5$</td>
<td>0.0385</td>
<td>0.0317</td>
<td>0.833</td>
<td>$\delta_5$</td>
<td>0.1292*</td>
<td>0.0680</td>
<td>2.011</td>
</tr>
<tr>
<td>$\delta_6$</td>
<td>0.0135</td>
<td>0.0175</td>
<td>0.293</td>
<td>$\delta_6$</td>
<td>0.0674</td>
<td>0.0614</td>
<td>1.049</td>
</tr>
<tr>
<td>$\delta_7$</td>
<td>0.0002</td>
<td>0.0025</td>
<td>0.004</td>
<td>$\delta_7$</td>
<td>0.0002</td>
<td>0.0025</td>
<td>0.002</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>0.0067***</td>
<td>0.0005</td>
<td>0.629</td>
<td>$\gamma_1$</td>
<td>0.0066***</td>
<td>0.0005</td>
<td>0.549</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>0.0060***</td>
<td>0.0002</td>
<td>0.597</td>
<td>$\gamma_2$</td>
<td>0.0060***</td>
<td>0.0002</td>
<td>0.524</td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>0.0015***</td>
<td>0.0001</td>
<td>0.296</td>
<td>$\gamma_3$</td>
<td>0.0015***</td>
<td>0.0001</td>
<td>0.261</td>
</tr>
<tr>
<td>$\gamma_4$</td>
<td>0.0014***</td>
<td>0.0001</td>
<td>0.285</td>
<td>$\gamma_4$</td>
<td>0.0013***</td>
<td>0.0001</td>
<td>0.249</td>
</tr>
<tr>
<td>$\gamma_5$</td>
<td>0.0528***</td>
<td>0.0080</td>
<td>1.766</td>
<td>$\gamma_5$</td>
<td>0.0454***</td>
<td>0.0085</td>
<td>1.445</td>
</tr>
<tr>
<td>$\gamma_6$</td>
<td>0.0059***</td>
<td>0.0023</td>
<td>0.592</td>
<td>$\gamma_6$</td>
<td>0.0064*</td>
<td>0.0037</td>
<td>0.544</td>
</tr>
<tr>
<td>$\gamma_7$</td>
<td>0.0014***</td>
<td>0.0001</td>
<td>0.290</td>
<td>$\gamma_7$</td>
<td>0.0014***</td>
<td>0.0001</td>
<td>0.253</td>
</tr>
</tbody>
</table>

Log-likelihood: 2342.1520  Log-likelihood: 2358.9059

Note: For Model 1, the mean interest-rate differential in sub-period $P_i$ is calculated by $\hat{\delta}_i/(1 - \sum_j \hat{\phi}_j)$. For Model 2, it is calculated by $\hat{\delta}_i/(1 - \sum_j \hat{\phi}^{NC}_j)$ for $i = 1, 2, 3, 4, 7$; $\hat{\delta}_i/(1 - \sum_j \hat{\phi}^{C1}_j)$ for $i = 5$; and $\hat{\delta}_i/(1 - \sum_j \hat{\phi}^{C2}_j)$ for $i = 6$. For both models, the unconditional standard deviation of the interest-rate differential in sub-period $P_i$ is calculated by $\sqrt{\hat{\gamma}_i/(1 - \hat{\alpha} - \hat{\beta})}$. The asterisks *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.
Table 3: Estimation results of the SP-US three-month interest-rate differential

<table>
<thead>
<tr>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>Estimate</td>
</tr>
<tr>
<td>$\phi_1$</td>
<td>0.9121***</td>
</tr>
<tr>
<td>$\phi_3$</td>
<td>0.0819***</td>
</tr>
<tr>
<td>$\phi_C^1$</td>
<td>0.8561***</td>
</tr>
<tr>
<td>$\delta_1$</td>
<td>-0.0133***</td>
</tr>
<tr>
<td>$\delta_2$</td>
<td>-0.0009</td>
</tr>
<tr>
<td>$\delta_3$</td>
<td>-0.0146***</td>
</tr>
<tr>
<td>$\gamma_1$</td>
<td>0.0031***</td>
</tr>
<tr>
<td>$\gamma_2$</td>
<td>0.1265***</td>
</tr>
<tr>
<td>$\gamma_3$</td>
<td>0.0029***</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.3681***</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.4820***</td>
</tr>
</tbody>
</table>

Log-likelihood: 1568.2682

Log-likelihood: 1581.3584

Note: For Model 1, the mean interest-rate differential in sub-period $P_i$ is calculated by $\hat{\delta}_i/(1 - \sum_j \hat{\phi}_j)$. For Model 2, it is calculated by $\hat{\delta}_i/(1 - \sum_j \hat{\phi}_{jNC})$ for $i = 1$ and 3; and $\hat{\delta}_i/(1 - \sum_j \hat{\phi}_C^j)$ for $i = 2$. For both models, the unconditional standard deviation of the interest-rate differential in sub-period $P_i$ is calculated by $\sqrt{\hat{\gamma}_i/(1 - \hat{\alpha} - \hat{\beta})}$. The asterisks *, ** and *** denote statistical significance at the 10%, 5% and 1% levels of significance, respectively.
Table 4: Average correlation in different subperiods

<table>
<thead>
<tr>
<th>Subperiod</th>
<th>HK-US</th>
<th>SP-US</th>
<th>HK-SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-crisis</td>
<td>0.1764</td>
<td>0.0684</td>
<td>0.1562</td>
</tr>
<tr>
<td>Crisis</td>
<td>−0.0044</td>
<td>0.0090</td>
<td>0.1717</td>
</tr>
<tr>
<td>Post-crisis</td>
<td>0.1553</td>
<td>0.0408</td>
<td>0.1938</td>
</tr>
</tbody>
</table>
Figure 1: Three-month Interbank Rates of HK, SP and US

Figure 2: Three-month Interbank-Rate Differential: HK-US and SP-US