INTERBANK RATE BEHAVIOR AND FINANCIAL CRISIS: The Case of Hong Kong*

by

Yi-Chi Chen**

National Cheng Kung University

and

Kar-yiu Wong***

University of Washington

August 5, 2004

*This paper is prepared for the "Asian Crisis, IV: Financial Crisis and Economic Growth" conference to be held in Tokyo, Japan, August 30-31, 2004. Comments are most welcome. Needless to say, all remaining errors and shortcomings are ours. Financial support provided by the National Science Council of Taiwan to the first author, under grant number 93-2415-H-006-003, is gratefully acknowledged.

**Department of Economics & Graduate Institute of Political Economy, National Cheng Kung University, Tainan, Taiwan 701, <yichi@ncku.edu.tw>. ***Department of Economics, University of Washington, Seattle, WA 98195-3330, U. S. A., <karyiu@u.washington.edu>.

Abstract

Hong Kong has long been under a fixed exchange rate regime, relying on the currency board to maintain currency stability. Currency board is a rule-based system, but because of the gradual dilution of the rules started in the late 1980s as a result of a number of monetary reforms, the currency board has gradually emphasized more on discretion in setting its policy. Such change in the board's policy led to corresponding changes in the performance of interest rates. During the 1997–1998 Asian crisis, the volatility and high values of interest rates had triggered serious credit crunch, causing a downturn of the economy and an escalating pressure on the currency. The Hong Kong's government was forced to revert to a rule-based system to strengthen the currency board system.

With use of the interest rate differential between the Hong Kong dollar and the U.S. dollar, this paper attempts to examine empirically the impacts of these institutional changes on the Hong Kong's interest rate, and to evaluate the relative merit of rules versus discretion over three distinct regimes. Our results suggest that the stance of policy making is associated with stability of the interbank market and thus the credibility of the currency board. We employ a structural break model under the Bayesian framework so as to determine the number and the type of structural breaks that are unique to the series under consideration. In the sense that the timing of a regime change is estimated by the model, rather than given *ex ante*. Finally, our empirical results should shed a light on implications for monetary policies in Hong Kong and the dynamics of interest rate.

1. Introduction

Since the breakdown in the early 1970s of the Bretton Woods system, the choice of an exchange rate regime has received a considerable attention in the international finance literature.[1] A growing consensus is that a successful monetary regime should achieve price stability and output growth. In general, the trade flow effect and the insulation effect are commonly discussed for the relative merit of exchange rate systems. For example, the trade flow effect hypothesis implies that fluctuations in the exchange rate hinder international trade in goods and capital, thereby increasing volatility of domestic output measures and reducing growth of output (Cunningham and Vilasuso, 1994; Kim, 2000). On the other hand, Friedman (1953) stresses the advantage of flexible exchange rates on their insulation properties. The insulation effect justifies the flexibility of monetary environment associated with the floating system, and allows the government to use monetary and fiscal instruments to reach internal balance. Unlike a pegged exchange rate, the monetary authorities are not required to peg the local currency to a statutory rate. Thus, the economy can better adapt to the external shocks. The insulation effect emphasizes the independent monetary policy under the floating system. When the insulation effect dominates, the economy should experience a output instability in a lesser magnitude.

In addition, the movement of interest rate has vital implications for the pegged country like Hong Kong (HK) with a well-developed financial sector and a high degree of capital mobility. Under the currency board system, stability of the HK's exchange rate depends on an automatic interest rate adjustment mechanism—interest rate arbitrage. For instance,

when banks sell U.S. (US) dollars to the Hong Kong Monetary Authority (HKMA), the HK's *de facto* central bank, the inflow of funds will lead to expansion of the monetary base; on the other hand, when banks sell HK dollars to the HKMA, the contraction of the monetary base will occur. The changes of monetary base will cause interest rates to fall or rise accordingly, creating the market conditions conducive or counteracting to capital inflows so as to restore exchange rate stability. Therefore, the credibility of the HK's currency board regime is maintained through the working of the interest rate adjustment. Since the late 1980s HK has initiated several monetary reforms to strength its currency. The consequences of these institutional changes have dictated HK's macroeconomic performance in the next decade and how well HK fared in the 1997-1998 Asian crisis. In particular, Kwan et al. (1999) point out, "... the volatile and high interest rate had caused a serious credit crunch in the banking system. In fact, Hong Kong's real GDP experienced a 5 percent decline in 1998, mainly as a result of the credit crunch. As the harmful effects persisted, people might question the wisdom of keeping the currency board, thus creating further pressure on the currency".

The empirical research on the evaluation of the currency board system mainly focused on movements of prices and output, only a few has paid attention to the importance of interest rates on economic performance. Recent studies by Tse and Yip (2002a, 2002b) address the impacts of exchange rate systems on interest rate behavior. Based on an event study, they conclude that HK's four major monetary reforms since 1988 have affected its interest rate movements. Cheng et al. (1999b) maintain that the effectiveness of these reforms dictates the well-being of the interbank market and the credibility of HK's currency

peg. In the view of Kwan et al. (1999), the HK's monetary regimes in the late 1980s have experienced three stages: a rule-bound regime, followed by a discretion-reliance regime, and then back to a rule-based regime. The shifts in policy making change the public confidence to a different degree and may have made HK an easy target to speculative attacks during the Asian financial crisis. Therefore, it is of our interest to study the reaction of the interbank market to the HK's *status quo*. The policy suggestions for the HK government to follow rules or to rely on discretion are offered.

In this paper, we attempt to provide empirical evidence of the HK's interest rate series to address the following issues: (1) What properties of the dynamics of the series across different monetary policy regimes? (2) What are the implications associated with the regimes identified by the model? (3) What is the relative merit of a rule-bound regime and a discretion-based regime? (4) What are the impacts of interest rate fluctuations on the credibility of the HK's currency board system during the 1997-1998 Asian crisis?

This paper is organized as follows. Section 2 briefly overviews the monetary regimes in HK, with an emphasis on the major monetary changes since the late 1980s and how interest rate was responded. Section 3 outlines the methodology for the empirical investigations. Specifically, we employ structural break models in the context of a Bayesian approach to determine the number and the type of structural changes in the series under consideration. The occurrence of structural breaks as a switch in monetary regimes is obtained in the estimation. Sections 4 examines the series of interest rate and discuss the effect of monetary regimes on the interbank market and on the credibility of the HK's currency peg. Section 5 explores interest rate movement during the Asian crisis of 1997-1998. Section 6 offers

concluding remarks.

2. Historical Background of HK's Currency Board

In the nineteenth and the early twentieth centuries, HK, like China, was on the silver standard. In 1935, as a result of the failure to stop huge silver outflows induced by the US silver purchase program, China and HK abandoned the silver standard. On December 6, 1935, an Exchange Fund was established under the Exchange Fund Ordinance. HK nationalized all privately held silver coins, and three designated note-issuing banks were required to turn over all their silver holdings and receive non-interest-bearing Certificates of Indebtedness (CIs) that entitled them to issue notes in return. The Exchange Fund in turn sold the silver holdings for sterling and invested in sterling assets. From that day onward, in order to issue more notes, the note-issuing banks were required to buy more CIs in sterling from the Exchange Fund at the fixed rate of HK$16.45 = £1. The Exchange Fund can control the growth of money supply through buying or selling CIs to the banks.[2]

Except for four years of Japanese occupation (December 1941 to August 1945), the link between the HK dollar and the sterling remained intact for more than three decades (from December 6, 1935 to June 23, 1972), until the post-World War II period when sterling devaluations undermined the existing parity. After the second sterling devaluation in November 1967, the inflationary pressure made it costly to peg the base currency to the sterling. In July 1972, after the sterling was forced to float, the HK government decided to abolish the peg to the sterling and to link its currency to the US dollar at the rate of US$1 = HK$5.65. However, the US dollar was not free from speculative attacks. Following the second devaluation of the US dollar in 1973 and an inflow of capital to HK in 1974, the HK

government was forced to let the HK dollar freely float against the US dollar on November 26, 1974. At that point, the first currency board system in HK ceased to operate.

During the period of the free-floating system from 1974 to 1983, the Exchange Fund still sold CIs to the note-issuing banks for the HK dollar. Under this system, the Fund maintained a deposit account with these banks, and a purchase of CIs was simply a transfer of credit from the bank to the Exchange Fund's account. From May 1979 onward, the Exchange Fund required the banks to maintain 100 percent liquid-assets to cover against the Fund's short-term deposits, which was intended to control the money supply originating from the banks. However, the requirement did not effectively limit the creation of HK dollar credit since the banks could borrow foreign currency to acquire the liquid assets. Thus, it led to the higher and volatile money growth during the 1970s than under the previous currency board system.

During the early stage of the floating period, the value of the trade-weighted HK dollar stayed fairly stable until 1982.[3] In September 1982, the diplomatic negotiations between China and Britain on the future of HK began. The political uncertainty originating from the bilateral talks, coupled with the fear of China's eventual sovereignty, had led to capital flight, the collapse of the property and equity markets, banking crisis and panic selling of the HK dollar (Jao, 1998). As a result, on "Black Saturday," September 24, 1983, the exchange rate of the HK dollar for the US dollar had fallen to an all time low of HK$9.55.

In order to avert the further breakdown of the financial system, on October 15, 1983, the HK government announced the re-introduction of the currency board system. Two days later, the government fixed the exchange rate at US$1 = HK$7.8. The note-issuing

banks had to pay the US dollar to purchase the CIs from the Exchange Fund based on the official parity rate. The Fund had to keep US dollar reserves of 105 percent of the monetary base, and to invest the reserves partly in interest-bearing US government securities.

Since the late 1980s, HK has initiated several key monetary reforms to strengthen the credibility of currency board.[4] Before a necessary measure was taken in 1988, the Hong Kong and Shanghai Banking Corporation (HSBC) was in charge of the interbank clearing system. The HSBC was in a monopoly position to create money without requirement of foreign exchange backup. The loophole in the monetary system created a downward bias in the HK's interest rate. In July 1988, Accounting Arrangements were introduced to effectively control over interbank liquidity and thus interbank rates. By limiting the HSBC's ability to expand credit, the monetary reform reduced the gap between the local and the US interest rates. Since March 1990, the Exchange Fund has the right to issue Exchange Fund Bills similar to three-month US Treasury bills. In order to increase the level of interbank liquidity, the Liquidity Adjustment Facility (LAF) was open in June 1992 to act as a discount window for local banks. With the new instruments in hand (Exchange Fund Bills and LAF), the Hong Kong Monetary Authority (HKMA, its predecessor was the Office of the Exchange Fund) was empowered with function of open market operations.[5] The introduction of the facility helped reduce the volatility of the interest rate and the magnitude of the interest rate premium. Kwan et al. (1999) claim that the availability of these intervention tools has transferred a rule-based HK currency board into a discretion-dependent institution, in which the HKMA was actively pursuing discretionary interventions.

In March 1994, HK adopted the revised mode of monetary operations to prevent the

short-term interest rate from deviating the certain range set by the LAF. Such an active intervention is expected to contain the level and volatility of the interest rate premium. In the wake of devaluation of the New Taiwan dollar, the HK dollar came under a series of speculative attacks. The rising pressure on HK dollar has led to questioning the substainability of the peg by many people. To restore the market's confidence the HKMA issued seven technical measures to strengthen the currency board system.[6] Two important elements of the measures are the provision of an exchange rate guarantee of the aggregate balance (Convertibility Undertaking) and a modification to a previous version of discount window. The purpose of these two measures is to signal a strong commitment to the fixed rules of the currency board and to stabilize the interest rate.[7] On the other hand, these new institutions constrain the HKMA from exploiting the interest rate. Up to this stage, the stance of the HKMA returned to a rule-bound regime by abandoning the use of high interest rate as defense strategy.[8]

As noted by Schwartz (1993), HK's monetary institution has deviated from the traditional currency board after the introduction of intervention tools, with the HKMA more inclined to discretionary policy making. Thus, we can demarcate the monetary developments in HK since 1988 into three regimes, as the HKMA shifted from a rule-bound regime to a discretion regime, and then a comeback to a rule-based regime after adopting the new technical measures. These changes in HK's monetary regimes along with the introduction of institutional reforms during the period provide us an opportunity to evaluate the relative merit of rules versus discretion. In addition, we can further examine the impacts of the reforms in HK's currency board system on the interbank rates as the high and volatile

interest rate can cause a serious credit crunch in the banking system, and thus creating further pressure on HK's dollar.

3. Econometric Methodology

3.1. Structural Break Model

In the econometric literature, structural break refers to a change in the values of some of the non-constant regression parameters over time, when the econometric model is under dynamic shocks. There has been a large number of empirical studies that confirm the existence of trend-stationary models with multiple structural breaks. In addition to structural breaks in level and trend, recent studies have found that the break point can occur in variance. It is thus generally not realistic to assume a one-time break of a model that one is working with. Failure to allow multiple breaks, if they exist, can lead to false inference on unit root tests. In particular, without accounting for structural breaks in variance, the series tend to exhibit persistence of volatility (Lamoureux and Lastrapes, 1990).

Wang and Zivot (2000) extend the regime-switching models of Carline et al. (1992), Inclán (1993), and Stephens (1994) and then use several model selection criteria to determine the number and type of structural changes. Specifically, they use marginal likelihoods, posterior odds ratios and Schwarz's Bayes Information Criterion (BIC) to select the model with the appropriate pattern of structural breaks that better describes the data-generating process of the series. The model is analyzed in the Bayesian framework and the estimation is achieved via the Gibbs sampler.

Wang and Zivot (2000) also re-visit the empirical work by Garcia and Perron (1996) and Ben-David et al. (2003) on the US real interest rate and the US GDP series. Their

Bayesian approach accurately captures the break dates and generates reliable estimates of the models. In addition, they find that the version of the structural break model in Garcia and Perron, in which regime changes in mean and variance must occur at the same time, is too restrictive. In Wang and Zivot's model, such a restriction does not exist. In the next section, we will briefly describe the model and refer the reader to Wang and Zivot (2000) for technical details.

In order to examine the dynamics of the series, the model for allowing multiple structural breaks in level, trend and/or variance is generalized as follows:

$$y_t = a_t + b_t t + \sum_{j=1}^{r} \phi_j y_{t-j} + s_t u_t, \tag{1}$$

$$u_t|\Omega_t \sim iid\ N(0,1) \qquad \text{for} \quad t = 1, 2, \ldots, T$$

where Ω_t denotes all available information up to time t. In equation (1), the parameters a_t, b_t and s_t are subject to $m < T$ regime-shifting. The break dates are denoted by $k_1, k_2, \ldots, k_m$ and are allocated among the observations, i.e. $1 < k_1 < k_2 < \ldots < k_m \leq T$. Therefore, there are $m + 1$ regimes in T observations. Each regime i is characterized by a_t, b_t and s_t which are given by values of α_i, β_i and σ_i for $i = 1, 2, \ldots, m + 1$ and $k_{i-1} \leq t < k_i$ with $k_0 = 1$ and $k_{m+1} = T + 1$. The autoregressive parameters ϕ_j are assumed to be identical across regimes.

A number of empirical structural break models are embedded in the specification of equation (1). For example, to account for structural changes in both level and trend (holding the variance constant across regimes) in the series such as the GDP level, equation

(1) can be written as (henceforth **Design I**):

$$y_t = a_t + b_t t + \sum_{j=1}^{r} \phi_j y_{t-j} + \sigma u_t, \quad t = 1, 2, \ldots, T, \tag{2}$$

where $a_t = \alpha_1, \alpha_2, \ldots, \alpha_{m+1}$ and $b_t = \beta_1, \beta_2, \ldots, \beta_{m+1}$. For data such as the inflation and the interest rate, the data-generating process may undergo the regime switching only in mean and variance without obvious trend effect (henceforth **Design II**):

$$y_t = a_t + \sum_{j=1}^{r} \phi_j y_{t-j} + s_t u_t, \quad t = 1, 2, \ldots, T, \tag{3}$$

where $a_t = \alpha_1, \alpha_2, \ldots, \alpha_{m+1}$ and $s_t = \sigma_1, \sigma_2, \ldots, \sigma_{m+1}$. Finally, we also employ the following two specifications as sensitivity tests for Designs I and II. Specifically, the structural break model in mean, trend and variance (henceforth **Design III**):

$$y_t = a_t + b_t t + \sum_{j=1}^{r} \phi_j y_{t-j} + s_t u_t, \quad t = 1, 2, \ldots, T, \tag{4}$$

and the breaks only occur in level (henceforth **Design IV**):

$$y_t = a_t + \sum_{j=1}^{r} \phi_j y_{t-j} + \sigma u_t, \quad t = 1, 2, \ldots, T, \tag{5}$$

Overall, equations (1) through (5) can be expressed in a matrix form as:

$$y_t = x_t' \mathbf{B} + s_t u_t, \tag{6}$$

where $x_t' = [I_{k_{i-1} \leq t < k_i} \qquad t \cdot I_{k_{i-1} \leq t < k_i} \qquad y_{t-j}]$ and $\mathbf{B} = (\alpha_i,\ \beta_i,\ \phi_j)$ for $i = 1, 2, \ldots, m+1$ and $j = 1, 2, \ldots, r$. I_E is an indicator variable for event E. The vector of unknown

parameters in equation (1) is $\theta = (\mathbf{B}', \sigma', k')$. Given the normality assumption and the observed data $\mathbf{Y} = (y_1, \ldots, y_T)$, the likelihood function of (6) is of form:

$$L(\theta|\mathbf{Y}) \propto \left(\prod_{t=1}^{T} s_t\right)^{-1} \exp\left\{-\frac{1}{2}\sum_{t=1}^{T}\frac{(y_t - x_t'\mathbf{B})^2}{s_t^2}\right\}. \tag{7}$$

where $\propto$ stands for proportionality since the density function in equation (7) ignores a normalized constant.

3.2. Determination of the Number of Structural Breaks

In order to determine the number of structural breaks in the time series, the flexibility of the Bayesian approach facilitates the tackling of the problem of multiple breaks as Wang and Zivot (2000) indicate. First of all, the candidate models for comparisons do not have to be nested. Each competing model has its posterior probability for evaluation. Second, although the number of breaks is unknown, the Bayesian framework provides a natural way of determining the number of breaks as a model selection problem. With the posterior probability of a model, we can evaluate how likely it is that a model with m breaks will occur against another model with n breaks where $m \neq n$. In this study, we use the Schwarz's BIC for model comparison.[9]

The BIC for a model with m breaks can be used to determine the number of structural breaks and it is defined as:

$$BIC(m) = 2\ln L(\hat{\theta}_{MLE}|\mathbf{Y}) - \lambda \ln(T), \tag{8}$$

where the likelihood function of $L(\cdot|\cdot)$ is equation (7) evaluated at the posterior means of θ based on the output of the Gibbs sampler, and λ denotes the number of estimated

parameters in a m structural breaks model, with T observations of the series. By the definition of (8), the model with the highest posterior probability has a larger BIC value.[10]

4. Data of Interest and Empirical Findings

The data consist of monthly observations of the HK and US three-month interbank rates.[11] In order to evaluate the HK monetary reforms from the late 1980s, the data cover the period of 1986:1–2001:12. The interest rate differential is defined as the domestic interest rate (HK) minus the US interest rate.

Figure 1 depicts the three-month interbank rates of the two economies, and Figure 2 shows the three-month interest rate differentials between the HK and US rates. Figure 2 highlights the interest rate differentials rose significantly at the end of 1997 with an indication of the risk premium for holding the HK dollar during the crisis period. As weak confidence swamped in the market, the risk premium and thus the interest rate differential would keep rising without the proper functioning of interest rate arbitrage. For HK, the rise was significantly higher than that in the previous period as it was related to the defense of the currency board regime under the successive speculative attacks in 1997/1998.

In this section, we present the empirical results of structural breaks in HK interest rate differentials. The number of lags was chosen based on the AIC criterion from the ordinary least squares without assuming structural breaks. The result supported one lag models, and suggested that the higher-order lags are not significant under any sensible levels.

Table 1 displays the results of Bayesian estimation for the interest rate series in question. The results of the model selection which determine the number of breaks are tabulated

in Appendix. The second column of Table 1 shows the posterior means of the estimated parameters, followed by the unconditional means based on the estimates in the second column along with the autoregressive parameters. The fourth and fifth columns summarize the standard errors and medians associated with the estimates, respectively. The last two columns report the 95% quantile-based confidence intervals with respect to the estimation of particular parameters. The last row presents the posterior mode for possible break dates that are estimated by Bayesian inference. Finally, Figure 3 shows the posterior distribution of the break dates with the series under consideration in time.

In order to determine the number and the pattern of the structural breaks, we estimate the models with m breaks ($m = 0, 1, 2, \ldots, 6$), and then choose the model that maximizes the BIC criterion. Inferences are based on $2,000$ draws of Gibbs sampler, after dropping the first 500 simulation as the burn-in period.

In the case of HK-US interest-rate differential, the logarithm of the marginal likelihood and the BIC values for each model with m breaks are $\ln f(\mathbf{Y}|m = 0) = -268.46$, $BIC(m = 0) = -552.67$; $\ln f(\mathbf{Y}|m = 1) = -216.35$, $BIC(m = 1) = -464.22$; $\ln f(\mathbf{Y}|m = 4) = -127.66$, $BIC(m = 4) = -334.10$ and $\ln f(\mathbf{Y}|m = 5) = -115.42$, $BIC(m = 5) = -325.39$.[12] Obviously, the model with no structural breaks is not supported by the BIC. Thus, there is support for the existence of structural breaks in the series. Among the competing models with a given number of breaks in level and variance, the model with $m = 5$ breaks is favored by the BIC. To ensure that the form of the structural breaks in variance is robust, we also estimate the model with five breaks in level but with a constant variance over time. For this model, the logarithm of the marginal likelihood is -191.22

and the BIC is -450.72. Thus, the evidence is still in favor of the structural breaks in mean and variance over the one with constant variance.

With the structural break model ($m = 5$), the interest rate differential between HK and US is distinguished by five break dates over the period 1986–2001 (Figure 3), including one outlier identified in mid-1991. Each of them is associated with a major monetary reform in HK.

Table 1 provides the posterior estimates from the $m = 5$ model. The first break date occurs in June 1988 with the mean differential equal to -.650 (calculated from $\hat{\alpha}_1 = -.621$) and the mean volatility $\hat{\sigma}_1 = .915$. The significant and negative interest-rate differential means the level of HK interest rate is below the US level. In that sense, prior to the Accounting Arrangements of 1988, HK's largest commercial bank (the HSBC) was able to create money without an appropriate increase in the US dollar backup, causing a substantial downward bias of about 84 basis points ($= -.65 - .19$) in the HK-US interest rate differential. When the Accounting Arrangements were installed, the legal loophole as mentioned above was removed and the HSBC can only conduct interbank operations under a cap set by the HKMA, and hence the interest rate differential turned out to be positive after June 1988 as can be seen from $\hat{\alpha}_2$. HK's three-month interbank rate was about 19 basis points above the US counterpart. A comparison of the estimates of σ_1 and σ_2 shows that the Accounting Arrangements greatly diluted the role of the HSBC as a clearing bank and lowered the variability of the interbank rate. The volatility after the monetary reform was reduced to only one-third of $\hat{\sigma}_1$.

On top of the strong HK dollar since mid-1991, the rising price level in April 1991

misled the HK officials to using contractionary monetary policy by withdrawing HK$100 million from the interbank market (Tsang, 1999). The Hong Kong Association of Banks (HKAB) responded the drain of liquidity by raising interest rates in May 1991, and the other banks followed suit. Although the HKAB cut down the interest rates in the following month, the activist monetary policy was under severe criticisms. As Bowring (1991) comments, "Trying to tackle inflation with interest rates shows a woeful lack of understanding of the system [the currency board]". As a result, the interest rate spreads went up to 2.120 as measured by $\hat{\alpha}_3$ in Table 1.

Despite a temporary surge in mid-1991, HK's interest rate almost converged to the US interest rate later in a month. Over the period from mid-1991 to early 1997, several economic developments in HK helped the interbank market stabilize and reduced the risk premium relative to the US rate: the LAF, the HK version of discount window, was introduced in 1992 and the HKMA adopted an interest rate target in 1994. The spreads of interest rates between HK and the US were close to zero and the volatility of the differential was significantly reduced, as indicated by $\hat{\alpha}_4$ and $\hat{\sigma}_4$ in Table 1.

For the impacts of the Asian financial crisis, the implied mean for $\hat{\alpha}_5$ in Table 1 is 1.21, suggesting that the Asian financial crisis did lead to a hike in HK's three-month interbank rate versus the US counterpart. Also, the results in Table 1 show that $\hat{\sigma}_5 = 2.427$, a measure that is significantly higher than those in the previous periods. This suggests that the regional economic turmoil did not only cause an increase in HK's interest rate, but also higher volatility in the interest-rate differential. In some sense, the HKMA was responsible for the volatile interbank market. As the speculative attacks against the HK dollar occurred

repeatedly in late 1997, the HKMA had used the strategy of high interest rate defense. At one point, the interbank rates shot up to 300 percent briefly in late October 1997 (Cheng et al., 1999b). The drain of interbank liquidity and the unprecedented high interest rates have caused a great pain in both business and banking sectors.

The impact of the economic downturn caused by the Asian crisis on HK's interest rate was manifested by the 1.2% risk premium on HK's interbank rate. One possible explanation is that during the crisis period, HK failed to allow its currency to depreciate against the US dollar in order to cushion the shocks and to ease the rising pressures on HK's interest rates. In other words, the rigidity of the currency peg in HK failed to devalue the HK dollar in face of external shocks. Therefore, interest rates have to contain the burden of shocks. Figure 3 indicates that the sustainability of the currency board regime during the Asian crisis was achieved at the expense of the interest rates as the risk premium rose significantly. The standard deviation of the HK interest rate differential was about 243 basis points, a relatively high variability in magnitude. In sum, the higher interest rate premium and variability were responsible for deepening recession in HK during the Asian crisis.

The failure of high interest rate defense along with the painful recession from the credit crunch forced the HKMA to issue the technical measures in order to strengthen the linked system. With the introduction of technical measures in the anti-crisis package and the eventual fading out of the crisis, the HK three-month rate once again fell to the US level during the post-crisis period. As the estimates shown in Table 1, there are two striking features in the post-crisis period: The level of the HK-US interest rate differential

decreased substantially from 1.21 basis point during the crisis period to the estimate of α_6 close to zero. Similarly, a significant reduction in volatility was observed from 2.427 to .264. The narrowing down and the stability of the interest rate differential between the US and HK dollars is likely attributable to the effective anti-crisis measures.

From 1988 to 1999, the HKMA was pro-actively using discretionary measures to intervene in the interbank market. They strongly believe that manipulating the interest rate can deter the vicious speculative attacks and maintain the exchange rate stability. On the other hand, during the financial crisis such unnecessary intervention policy was vulnerable to public criticisms and market pressure. It was until the technical measures were adopted in late 1998 that the HKMA reverted to the rule-based system again. Therefore, we can consider that HK's monetary regimes have experienced three major stages since the currency board system re-installed in 1983: a rule-bound regime until mid-1988, a discretion-reliant regime from 1988 through the crisis period in early 1999, and then a return to a rule-based regime from 1999 onward.

Based on our results in Table 1, the relative merit of rules versus discretion can be evaluated. Throughout the discretion regime when the HKMA actively use the intervention instruments, the interest-rate differential remained relatively high in level and volatility. On average, the interest-rate differential was about .89 basis point whereas the average spreads in two ruled-bound regimes stayed close to zero. The same result can be inferred from comparison of the volatility of the interest-rate differentials across three regimes. The interbank market was relatively stable without the active interventions by the HKMA. Therefore, it seems to suggest that it is better for the HKMA to use passive policy making

and allow the system to go on 'auto-pilot'.

Finally, our model can be considered as an improvement over the GARCH model used in Tse and Yip (2002a, 2002b). First, the break points in the series are not determined *ex-ante* in our analysis. Tse and Yip divide the sample period based on the certain economic events which are not data-dependent. Second, by accounting for the structural changes in mean and variance, our estimates are more reliable, while their estimation without such dynamic features produces highly persistent autoregressive coefficients. Third, as Doornik and Ooms (2000) have rigorously shown that the feature of dummies in the GARCH specification could lead to a multimodality problem in the sense that the statistical inferences may not be reliable. Fourth, the quasi-maximum likelihood (QML) estimation of the GARCH model was implemented by Tse and Yip (2002a, 2002b). However, Engle and González-Rivera (1991) suggest that the precision of the QML estimator may be low which could compromise the power of the hypothesis tests. Finally, the GARCH(1,1) specification was chosen without a formal model selection process. Under the Bayesian framework we are able to select a better model in comparison of posterior probabilities, and thus the sub-optimal problem can be considerably reduced.

5. Credibility of the Currency Board Regime during Asian Crisis

In this section we further discuss the relationship between interest rate movement and the credibility of the HK's exchange rate system during the 1997–1998 financial turmoil. According to uncovered interest rate parity, the interest rate differential between the domestic and foreign countries is equal to the expected depreciation/appreciation of the local currency. If the differential appears to be large, it may lead to an expected appreciation

of the spot rate in the future and signal that the currency peg system is less credible. Thus, the interest rate differential is commonly used as predictors of currency crises.[13] Furthermore, Galindo (2001) base on Bertola and Caballeros' (1992) theoretical argument to estimate credibility of Colombia's exchange rate target zone. His empirical findings show that the volatility of the interest rate differential increases as credibility decreases.

The credibility of the HK's linked exchange rate during the crisis period can be inferred from Table 1. If we consider the period July 1997 through February 1999 as the crisis period. As shown in Table 1, the volatility of the interest rate differential in this regime reached at 2.427, measured by $\hat{\sigma}_5$, a substantial increase in magnitude as opposed to that before the outbreak of the Asian crisis. To some extent we can interpret the large interest rate fluctuations as the rising pressure on the HK dollar. This result can be confirmed by Figure 4 where it shows the spot exchange rate between HK and US dollars over the period 1996 to 2001. The exchange rate fluctuates between 7.74 and 7.75 since 1996 except for the big dip (or appreciation) in October 1997 when the first attack on HK dollar was launched. Our estimation shows that the break point of such a variance change occurs in July 1997, implying the HK dollar came under pressure of appreciation long before the actual speculative attacks started.[14] Only until February 1992 did the establishment of technical measures lower the volatility of the interest rate differential to .264, almost 10 times less than what it was during the crisis period. A stable interest rate also restored the public confidence on the currency, the credibility of the peg improved after adopting technical measures. Finally, the result in this section also imply that the exercise of discretionary powers is not an effective tool to strengthen the credibility of currency board

as the volatility of the interest rate tends to be higher.

6. Conclusions

Hong Kong's monetary developments since the late 1980s provide us a unique natural experiment to study the macroeconomic implication of the interest rate differential. Its experiences of monetary reforms and the Asian financial crisis also reflects the trends of HK's monetary regimes from rules to discretion. Our empirical results obtained from the structural break model show that HK's institutional changes caused different dynamics of interest rate, and the HKMA's engagement in more discretionary interventions in the money market might have produced unfavorable recession during the crisis period.

Our results indicate that in the absence of the Accounting Arrangements in 1988, the HSBC was able to take advantage of creating money without a parallel amount of foreign exchange backup, causing a downward bias in the HK-US interest-rate differential. The introduction of the Accounting Arrangements has limited the ability of the HSBC to expand credits, as a result, the HK-US interest-rate differential returned to positive and the volatility greatly reduced.

The empirical evidence also shows that the adoption of the LAF and acquirement of other new intervention tools in the 1990s led to a reduction in both the level and volatility of the interest-rate differential, except for a temporary surge in mid-1991. We also found that the impacts of the Asian financial crisis in 1997–1998 were substantial: the level and volatility of the interest rate differential were unprecedentedly high, causing the deepening recession and the severe credit crunch at that time. Fortunately, the timely anti-crisis packages implemented in late 1998 dramatically reduced the level and volatility of the

HK's interest rate as the measures effectively increased market's confidence in the peg.

This paper also discusses the stances of the monetary policy across three regimes. The HKMA's active involvement in the money market tends to disturb the tranquility of interest rate by raising the level and the volatility. Instead, the HKMA should adhere to the fixed rules without the use of any discretionary interventions. Our observation is in fact consistent with what Kwan et al. (1999) indicates, "[Currency board's] credibility, however, depends critically on whether the government has the reputation for strictly following fixed rules, rather than relying on discretion".

FOOTNOTES

1. For example, Mishkin (1999) provides a critical view of different types of monetary policy regimes. Calvo and Mishkin (2003) and Levy-Yeyati and Sturzenegger (2003) study the impacts of the choice of exchange rate on macroeconomic performance.
2. For discussions of developments of the HK's currency board, see Schuler (1992), Schwartz (1993) and Williamson (1995).
3. See Table 1 in Jao (1998).
4. See Tse and Yip (2002b) for further details on the currency board reforms in HK and their impacts on the interbank market.
5. The HKMA was created in April 1993 by merging the Office of the Exchange Fund with the Office of the Commissioner of Banking. For its specific functions and objectives, see the HKMA's web page at *http:// www.info.gov.hk/hkma/gdbook/eng/h/hkma.htm*.
6. The HKMA took recommendations from researchers by issuing the conceptually-equivalent HK dollar put option. The provision of the rule-based scheme reduces substantially the exchange risk of the banks. See Chan and Chen (1999), Cheng et al. (1999b), and Lui et al. (1999) for detailed accounts of the design of put options.
7. In fact, there is the eight technical measure announced in September 1998 in which the HKMA made a more explicit guarantee concerning the length of the period of the Convertibility Undertaking, see Cheng et al. (1999b) for the details of the measure.
8. This view is shared by Cheng et al. (1999a), "... these measures [technical measures] reflected a fundamental reversal of the HKMA's prior conviction that high interest rate was a necessary evil in fighting against currency speculators and signaled an

acceptance of the argument that the HKMA needed to take concrete actions, not mere words, to boost confidence in the peg".

9. Wang and Zivot (2000) also use other posterior odds ratios associated with two different prior distributions of structural breaks. Using Monte Carlo simulations, however, they show that the BIC consistently selects a correct model among three selection criteria. Thus, the BIC is considered as a reliable criterion.
10. Note that our definition of the BIC is different from the one used in Wang and Zivot (2000). In other words, the BIC they choose is the negative version of ours so that they select the model with the smallest BIC value.
11. The interest rate for HK is the interbank rate. The corresponding interest rate for the US is the Eurodollar rate LIBOR (London Interbank Offered Rate) which is also an interbank rate. Specifically, it is an average of London bank quotes at 11 a.m. London time. Some 20 quotes are taken, the highest and lowest are removed.
12. See Appendix for a complete result of the model selection.
13. Blanco and Garber (1986), Grilli (1990), Goldberg (1994) and Miller (1996) make use of the interest rate differential to estimate the probabilities of speculative attacks. Flood and Rose (2002) base on uncovered interest parity to predict occurrence of currency crises of the 1990s, but the results are mixed.
14. In the case of Colombia, Galindo (2001) also detects a drop of credibility of the exchange rate target zone before the international financial turbulence.

REFERENCES

Ben-David, D., R. L. Lumsdaine and D. H. Papell, (2003). "Unit Roots, Postwar Slowdowns and Long-Run Growth: Evidence from Two Structural Breaks," *Empirical Economics, Vol. 28*, pp. 303–19.

Bertola, G. and R. Caballero, (1992). "Target Zones and Realignments," *American Economic Review, Vol. 82*, pp. 520–36.

Blanco, H. and P. Garber, (1986). "Recurrent Devaluation and Speculative Attacks on the Mexican Peso," *Journal of Political Economy, Vol. 94*, pp. 148–66.

Bowring, P., (1991). *The Ruling Asses*, *Far Eastern Economic Review, Vol. 6*, p. 58.

Calvo, G. A. and F. S. Mishkin, (2003). "The Mirage of Exchange Rate Regimes for Emerging Market Countries," *Journal of Economic Perspectives, Vol. 17*, pp. 99–118.

Carlin, B. P., A. E. Gelfand and A. F. M. Smith, (1992). "Hierarchical Bayesian Analysis of Changepoint Problems," *Applied Statistics, Vol. 41*, pp. 389–405.

Chan, W. H. and N. F. Chen, (1999). "An Intertemporal Currency Board," *Pacific Economic Review, Vol. 4*, pp. 215–232.

Cheng, L. K. Y. K. Kwan and F. T. Lui, (1999a). "Risk Premium, Currency Board, and Attacks on the Hong Kong Dollar," *mimeo*, Hong Kong University of Science and Technology.

Cheng, L. K. Y. K. Kwan and F. T. Lui, (1999b). *An Alternative Approach to Defending The Hong Kong Dollar*, *mimeo*, Hong Kong University of Science and Technology.

Cunningham, S. R. and J. Vilasuso, (1994). "Comparing U. S. GNP Volatility across

Exchange Rate Regimes: An Application of Saphe Cracking," *Journal of Macroeconomics, Vol. 16*, pp. 445–59.

Doornik, J. A. and M. Ooms, (2000). "Multimodality and the GARCH Likelihood," *mimeo.*, University of Oxford and Erasmus University Rotterdam.

Engle, R. F. and G. González-Rivera, (1991). "Semiparametric ARCH Models," *Journal of Business and Economic Statistics, Vol. 9*, pp. 345–59.

Flood, R. and A. Rose, (2002). "Uncovered Interest Parity in Crisis," *IMF Staff Papers Vol. 49*, pp. 252–66.

Friedman, M., (1953). "The Case for Flexible Exchange Rates," in: M. Friedman, eds., *Essays in Positive Economics*, Chicago: University of Chicago Press.

Galindo, A. J., (2001). "The Credibility of the Colombian Exchange Rate Target Zone: its Impact over the Volatility of Interest Rate Differentials," *Quarterly Review of Economics and Finance, Vol. 41*, pp. 111–18.

Garcia, R. and P. Perron, (1996). "An Analysis of the Real Interest Rate Under Regime Shifts,' *Review of Economics and Statistics, Vol. 78*, pp. 111–25.

Goldberg, L., (1994). "Predicting Exchange Rate Crises: Mexico Revisited," *Journal of International Economics, Vol. 36*, pp. 413–30.

Grilli, V., (1990). "Managing Exchange Rate Crises: Evidence from the 1890s," *Journal of International Money and Finance, Vol. 9*, pp. 258–75.

Inclán, C., (1993). *Detection of Multiple Changes of Variance Using Posterior Odds*, *Journal of Business and Economic Statistics, Vol. 11*, pp. 289–300.

Jao, Y. C., (1998). "The Working of the Currency Board: The Experience of Hong Kong

1935-1997," *Pacific Economic Review, Vol. 3*, pp. 219–41.

Karamouzis, N. V., (1984). "The Use of the Interest Rate Differential in Empirical Studies," *Atlantic Economic Journal, Vol. 12*, p. 77.

Kim, J., (2000). "The Relationship between the Monetary Regime and Output Volatility: a Multivariate GARCH-M model of the Japanese Experience, 1919–1996," *Japan and the World Economy, Vol. 12*, pp. 49–69.

Kwan, Y. K., F. T. Lui, and L. K. Cheng, (1999). "Credibility of Hong Kong's Currency Board: The Role of Institutional Arrangements," *mimeo.*, Hong Kong University of Science and Technology.

Lamoureux, C. G. and Lastrapes, W. D., (1990). "Persistence in Variance, Structural Changes and the GARCH Model," *Journal of Business and Economic Statistics, Vol. 8*, pp. 225–34.

Levy-Yeyati, E. and F. Sturzenegger, (2003). "To Float or to Fix: Evidence on the Impact of Exchange Rate Regimes on Growth," *American Economic Review, Vol. 93*, pp. 1173–93.

Lui, F. T., L. K. Cheng and Y. K. Kwan, (1999). "An Alternative Approach to Defending the Hong Kong Dollar," *mimeo.*, Hong Kong University of Science and Technology.

Miller, V., (1996). "Exchange Rate Crises with Domestic Bank Runs: Evidence from the 1890s," *Journal of International Money and Finance, Vol. 15*, pp. 637–56.

Mishkin, F. S., (1999). "International Experiences with Different Monetary Policy Regimes," *Journal of Monetary Economics, Vol. 43*, pp. 579–605.

Schuler, K. A., (1992). "Currency Boards," *Ph.D. dissertation*, George Mason University.

Stephens, D. A., (1994). "Bayesian Retrospective Multiple Changepoint Identification," *Applied Statistics, Vol. 43*, pp. 159–78.

Schwartz, A. J., (1993). "Currency Boards: Their Past, Present and Possible Future Role," *Carnegie-Rochester Conference Series on Public Policy, Vol. 39*, pp. 147–87.

Tsang, S. K., (1998). "The Case for Adopting the Convertible Reserves System in Hong Kong," *Pacific Economic Review, Vol. 3*, pp. 265–75.

Tsang, S. K., (1999). "Fixing the Exchange Rate through a Currency Board Arrangement: Efficiency Risk, Systemic Risk and Exit Cost," *Asian Economic Journal, Vol. 13*, pp. 239–66.

Tse, Y. K. and S. L. Yip, (2002a). "Exchange-Rate Systems and Interest-Rate Behaviour: The Experience of Hong Kong and Singapore," *mimeo.*, Singapore Management University.

Tse, Y. K. and S. L. Yip, (2002b). "The Impacts of Hong Kong's Currency Board Reforms on the Interbank Market," *Journal of Banking and Finance, Vol. 27*, pp. 2273–96.

Wang, J. and E. Zivot, (2000). "A Bayesian Time Series Model of Multiple Structural Changes in Level, Trend, and Variance," *Journal of Business and Economic Statistics, Vol. 18*, pp. 374–86.

Williamson, J., (1995). "What Role for Currency Boards?," *Policy Analyses in International Economics, No. 40*, Washington DC: Institute for International Economics.

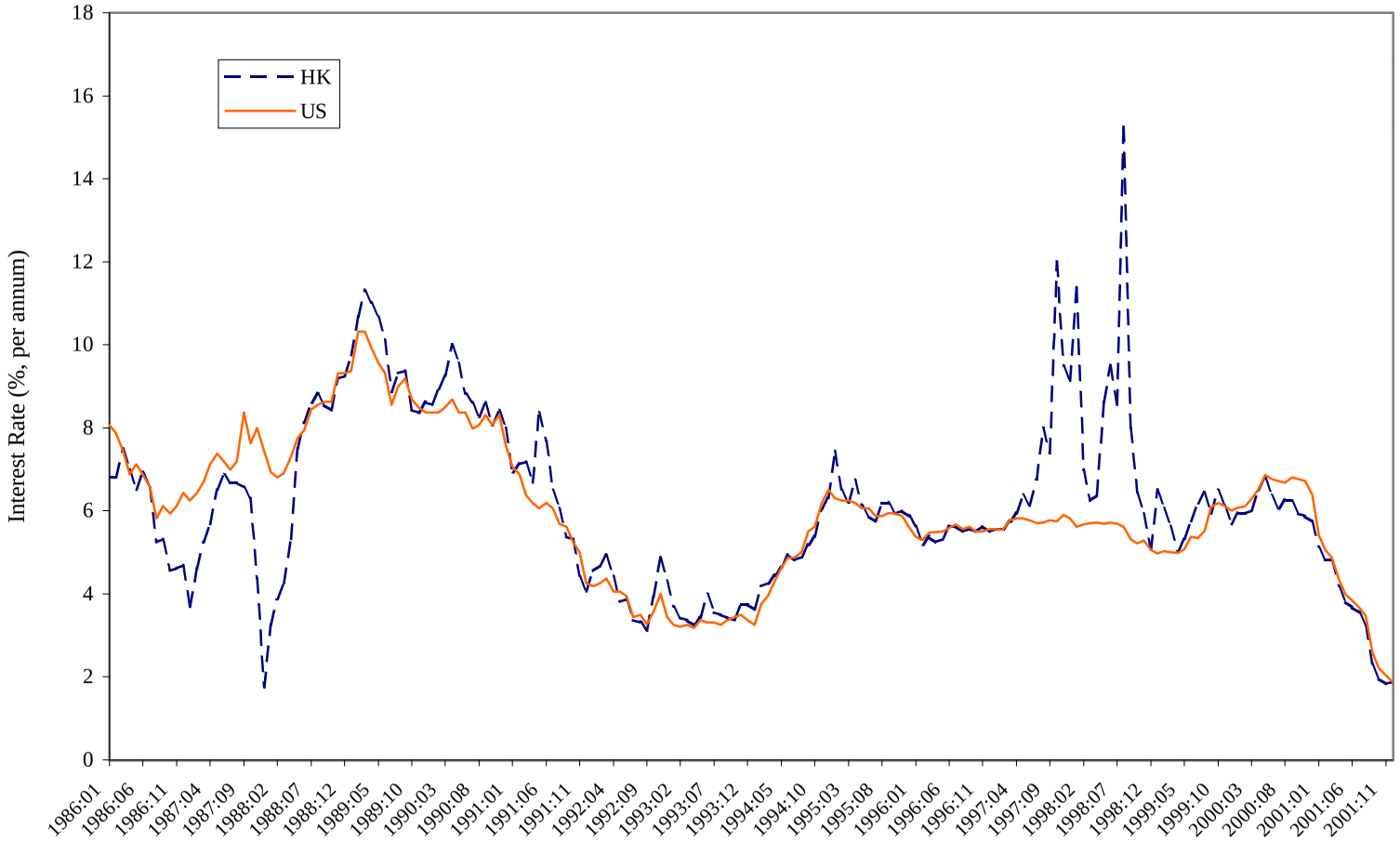

Figure 1 Three-Month Nominal Interbank Rates of HK and US

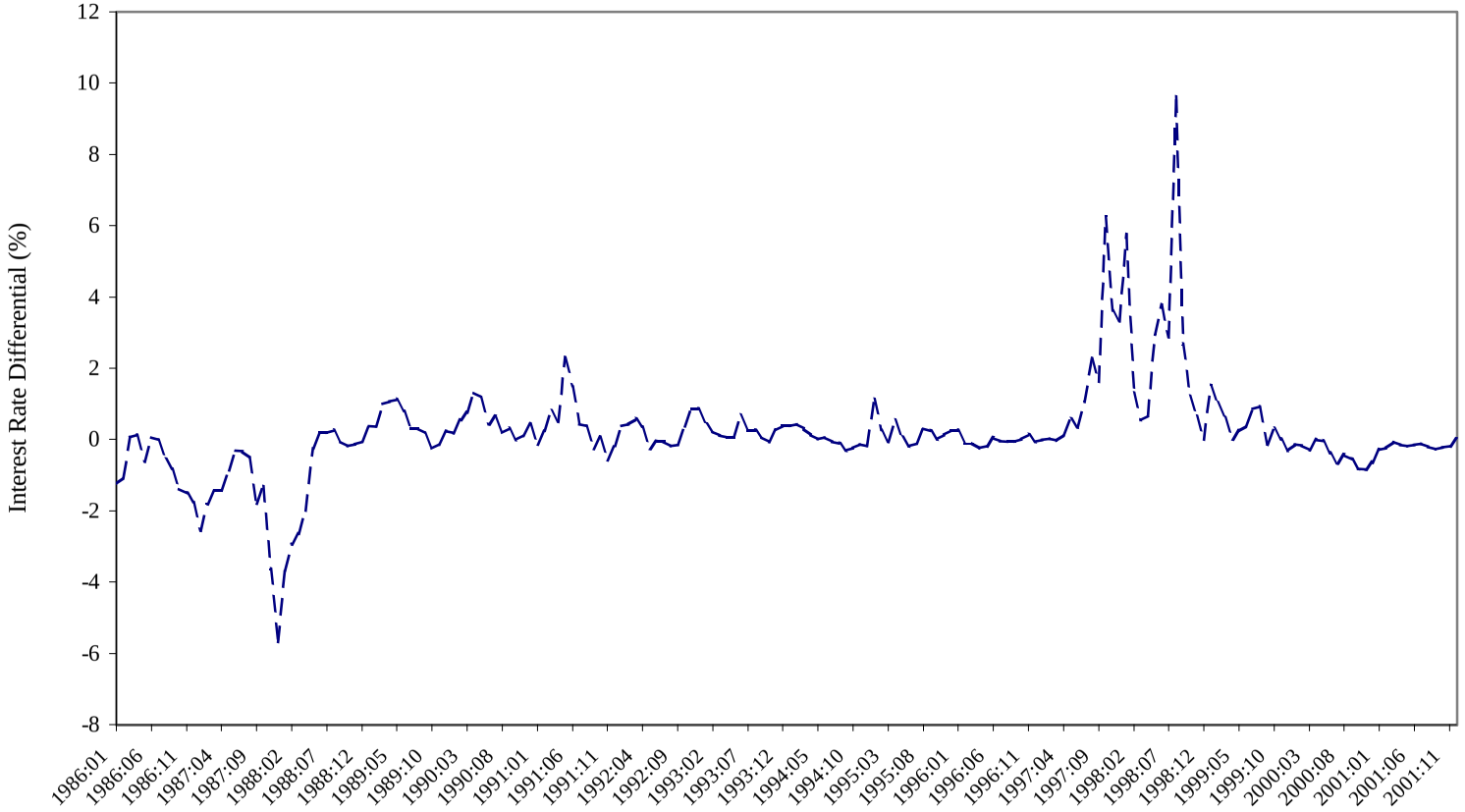

Figure 2 Three-Month Nominal Interbank Rate Differentials: HK-US

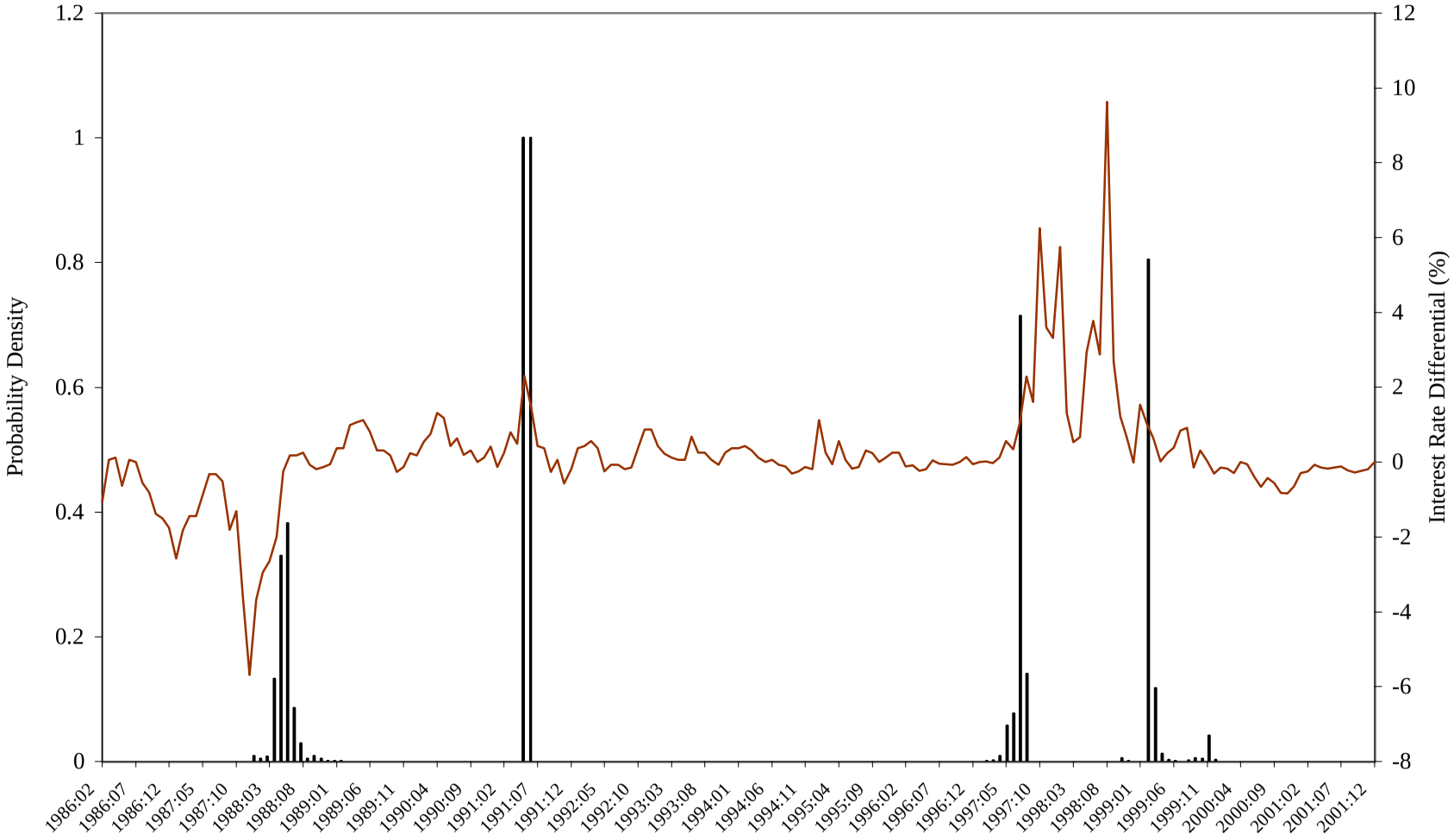

Figure 3 Three-Month Nominal Interbank Rate Differential: HK-US

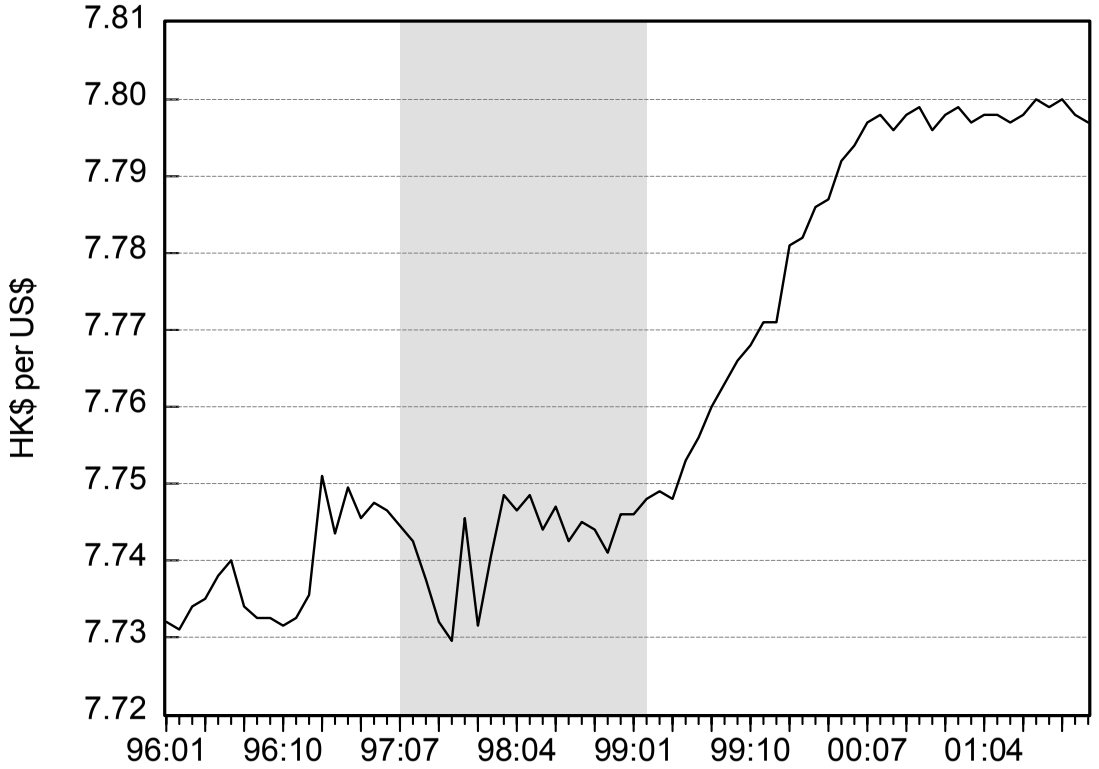

Figure 4. HK$/US$ Exchange Rate
1996:1--2001:12

Table 1 Parameter Estimates for Nominal Interbank Rate Differential: HK-US (1986:01~2001:12, per annum)

parameter	estimate	implied mean differential	std. error	median	95% confidence interval	
$\acute{a}_1$	-.621	-.650	.220	-.616	-1.023	-.232
$\acute{a}_2$	.176	.185	.068	.178	.056	.294
$\acute{a}_3$	2.025	2.120	.070	2.024	1.894	2.159
$\acute{a}_4$	.049	.051	.036	.048	-.019	.119
$\acute{a}_5$	1.156	1.210	.614	1.156	.002	2.300
$\acute{a}_6$	-.069	-.072	.066	-.067	-.169	.026
$\ddot{o}_1$	.576		.069	.577	.467	.681
$\acute{o}_1$	.915		.131	.900	.711	1.207
$\acute{o}_2$	.320		.045	.316	.252	.410
$\acute{o}_3$	.052		.086	.037	.017	.182
$\acute{o}_4$	.285		.027	.283	.241	.340
$\acute{o}_5$	2.427		.495	2.366	1.777	3.411
$\acute{o}_6$	.264		.065	.263	.173	.348
k_1 = 1988:06	k_2 = 1991:05	k_3 = 1991:06	k_4 = 1997:07	k_5 = 1999:02		

Note: The implied mean interest-rate differential is calculated by $\hat{a}_i /(1-\hat{f}_1)$.

Appendix

Model Selection Criteria

This appendix summarizes the results of the choice of model based the Schwarz' s Bayesian Information Criterion (BIC). The specification for each design is as follows:

Design I—structural breaks in mean and trend:

$$y_t = a_t + b_t t + \sum_{j=1}^{r} \phi_j y_{t-j} + \sigma u_t, \quad t = 1, 2, \ldots, T,$$

Design II—structural breaks in mean and variance:

$$y_t = a_t + \sum_{j=1}^{r} \phi_j y_{t-j} + s_t u_t, \quad t = 1, 2, \ldots, T,$$

Design III—structural breaks in mean, trend and variance:

$$y_t = a_t + b_t t + \sum_{j=1}^{r} \phi_j y_{t-j} + s_t u_t, \quad t = 1, 2, \ldots, T,$$

Design IV—structural breaks in level:

$$y_t = a_t + \sum_{j=1}^{r} \phi_j y_{t-j} + \sigma u_t, \quad t = 1, 2, \ldots, T,$$

Hong Kong: 3-month Nominal Interbank Rate Differential (AR(1), 1986:01~2001:12, N=192)

Design II							
m[a]	m=0	m=1	m=2	m=3	m=4	m=5	m=6
LLK[b]	-268.455	-216.353	-186.430	-175.716	-127.660	-115.424	-113.691
BIC[c]	-552.667	-464.220	-420.131	-414.458	-334.103	**-325.389**	-337.680
K[d]		139	29, 138	22, 24, 138	28, 116, 136, 157	29, 64, 65, 138, 157	29, 64, 65, 116, 136, 157
Design IV							
LLK						-191.219	
BIC						-450.717	
k						22, 27, 139, 151, 152	

Note:

a. The number of breaks in the model.

b. The marginal log-likelihood value.

c. The Schwarz's BIC is calculated by 2*LLK- λ*log(T) where LLK is the marginal likelihood value evaluated at MLE, λ is the number of parameters with m structural breaks and T is the number of observations. Thus, we choose the model that maximizes the BIC value. The maximum BIC value is highlighted in bold.

d. The posterior mode of the distribution of break points.