Risk Premium, Currency Board, and Attacks on the Hong Kong Dollar*

Leonard K. Cheng,[a] Yum K. Kwan,[b] and Francis T. Lui[a]

December 21, 1999

Abstract

Hong Kong's "linked exchange rate" (also known as the "peg") is a currency board system under which the Hong Kong dollar notes are fully backed by the U.S. dollar at the rate of HK$7.8 per US dollar. In this paper we present an event analysis of the credibility of the peg as measured by the forward premium recovered from forward exchange rates. Based on the forward premium from January 1997 to April 1999, the devaluation probability of the Hong Kong dollar as perceived by the foreign exchange market is calculated. We examine the evolution of credibility during this period using the theoretical framework of a target zone model. The relationship between Hong Kong dollar's risk premium during the recent Asian financial crisis and four fundamental economic variables whose deterioration is widely regarded as conducive to currency crisis is explored.

JEL: F31
Keywords: risk premium; forward premium; currency attack; currency board; Hong Kong dollar

Corresponding author: Leonard K. Cheng, Department of Economics, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong. Tel: (+852)-2358-7621; Fax: (+852)-2358-2084; Email: leonard@ust.hk.

* An earlier version of this paper was presented in a session on "Asian Financial Crisis: Taiwan, Hong Kong and Their Neighbors" at the American Economic Association Meetings, January 3-5, 1999, New York. The work described in this paper was substantially supported by a grant from the Research Grant Council of the Hong Kong Special Administrative Region, China (Project No. HKUST 6217/97H). We would like to thank Gregory Chow for helpful comments and Andrew Kao for effective research assistance.
[a] Hong Kong University of Science and Technology.
[b] City University of Hong Kong.

I. Introduction

In the recent financial crisis that swept across Asia, a common feature was that attacks on the local currencies led to their depreciation or even total collapse. The only East Asian currencies that have thus far not been forced to devalue are the Hong Kong dollar and China's Renminbi. The Hong Kong dollar is pegged to the U.S. dollar via a currency board arrangement called the "linked exchange rate system" (also known as "the peg"), whereas the Renminbi is not a fully convertible currency because China maintains control on cross-border capital movement.

Under Hong Kong's exchange rate system, Hong Kong dollar notes are more than fully backed by U.S. dollars at the rate of HK$7.8 per US dollar. In fact, given the staggering size of Hong Kong's reserve, every Hong Kong dollar note is much more than 100% backed. Even though the system has survived the Asian financial crisis thus far, it does not mean that it did not come under severe speculative pressure. Confidence in the system was actually in doubt during the crisis. In this paper, we analyze the foreign exchange market's perception of the realignment risks of holding the Hong Kong dollar vis-à-vis the U.S. dollar since the peg's inception in October 1983. We shall relate changes in the perceived risks to both development in the global financial markets and policy measures taken by Hong Kong's monetary authority in dealing with attacks on its currency. Special emphasis will be given to the period of the Asian financial crisis.

After an event analysis of the credibility of the peg in the next section, we shall examine in Section III the peg's credibility within the theoretical framework of a target zone model. Section IV explores the relationship between Hong Kong dollar's risk premium during the recent Asian financial crisis on the one hand and four fundamental economic variables whose deterioration is widely regarded as conducive to currency crisis on the other. These variables include Hong Kong's real exchange rate, trade balance, foreign reserves, and unemployment rate. The final section summarizes our findings and indicates directions for further research.

II. Risk Premium of the Hong Kong Dollar: An Event Analysis

In this section we analyze the risk premium of the Hong Kong dollar as perceived by the foreign exchange market since the peg's inception in October 1983. Following

Bartolini and Bodnar (1992), we shall measure the risk premium, or equivalently the lack of credibility of the peg, by the annualized premia of the 1-month, 3-month, 6-month, and 12-month Hong Kong dollar/U.S. dollar forward exchange rates. By definition, the forward premium is the annualized percentage deviation of the forward exchange rate from the spot exchange rate. A forward discount is understood to be a negative premium.

Under covered interest parity and in the absence of transaction costs, the annualized forward premium would be equal to the difference between Hong Kong interest rate (Hong Kong Inter-bank Offer Rate, or HIBOR for short) and the U.S. interest rate (London Inter-bank Offer Rate, or LIBOR for short) of the corresponding maturity.[1] An examination of the forward premium and interest rate differentials reveals that their differences are not significantly different from zero. Thus, the two measures essentially contain the same information about Hong Kong dollar's risk premium. However, in the presence of transaction costs, the relationship is not exact, so changes in one market would be partially transmitted or spilled over to the other. The Hong Kong Monetary Authority intervenes in both the foreign exchange spot market and the money market but not in the foreign exchange forward market. Thus, in the presence of transactions cost, the forward premium is arguably a better measure of the market's perceived risk of the Hong Kong dollar than the interest rate differential.

The spot exchange rate from November 1, 1983 to April 21, 1999 is given in Figure 1. Three observations are in order. First, the spot rate fluctuated around the official rate of HK$7.8/US$ between November 1983 and mid 1991. During this period, the spot rate remained within 7.75 and 7.85 most of the time, but exceeded 7.85 between July and September of 1984 and fell below 7.75 during July 1985. Second, due to the Hong Kong Monetary Authority's (HKMA, Hong Kong's de facto central bank) adoption of a "first-line defense" at 7.75 towards the end of May 1992, the spot rate has since hovered around 7.74-7.75, but staying below 7.75 more often than above it.[2] Third, the exchange rate rose above 7.76 in January 1995 as a result of the spillover from the Mexican crisis, but it has remained below 7.75 ever since the onset of the Asian financial crisis.

[1] See Lui, Cheng and Kwan (1999) for an analysis using HIBOR-LIBOR interest differentials.

[2] One can question the wisdom of adopting a first-line defense. If the HKMA fails to maintain its first-line defense of 7.75, it is doubtful that it will be able to defend the ultimate-line of 7.8.

(Insert Figure 1 here: Spot Exchange Rate)

The 1-month forward premium for the same period is depicted in Figure 2. As can be seen, the premium was close to zero throughout the entire period with several noticeable exceptions. In the first two years or so of the newly established peg, the market was understandably skeptical and concerned about the possibility of realignments. During December 1987 and the first two weeks of January 1988, the Hong Kong dollar enjoyed a very substantial risk discount, reaching a maximum of over 10% on December 22, 1987. During this period, the U.S. dollar depreciated against the Japanese yen as the U.S. ran a big budgetary deficit. Funds flowed into Hong Kong in anticipation of the Hong Kong dollar's appreciation in the event of a break of the peg. The inflow of hot money abated after the Hong Kong Government considered using negative interest rate to defend the peg.

From the middle of 1988 to the beginning of the Asian financial crisis, the 1-month forward premium remained very close to zero.[3] Even when the system was tested by shock waves such as the June 4 incident in 1989 and the Mexican crisis in January 1995, the risk premium only went up for a brief period and the annualized premium was remarkably below 3%.[4]

(Insert Figure 2 here: 1-month Forward Premium)

The situation during the Asian financial crisis appeared to be a break from the past. Figure 3 depicts the 1-month forward premium from April 1, 1997 to April 21,

---

[3] The period of relative tranquility was associated with the introduction of the New Accounting Arrangement by the HKMA. Before the New Accounting Arrangement, the Hong Kong Bank (the largest private bank in Hong Kong) served as a de facto central bank in terms of the banking system's settlement of transactions. With the New Accounting Arrangement, the Hong Kong Bank had to maintain an account with the HKMA for its own settlement. After December 9, 1996, all banks in Hong Kong must maintain a settlement account directly with the HKMA rather than through one of the former "clearing banks."

[4] Between early May and the third week of June 1991, the risk premium of the Hong Kong dollar was in the range of 2-3%. During this period, Hong Kong suffered from double-digit inflation and the prime lending rate went up by a full percentage point. The risk premium dropped after Hong Kong's inflation and growth rates slowed down.

1999. Compared with the earlier period, the risk premium was substantially higher. As the Hong Kong dollar came under a major speculative attack against the background of the New Taiwan dollar's float, the premium shot up to 15% on October 23, 1997, which is known as the "Black Thursday" in Hong Kong, when the overnight HIBOR at one point reached 280%. The risk premium reached 24% in the period of January 12-20,1998, when the currency came under another major attack. In the next two attacks in June and August 1998, the risk premium was 6-7.4% during June 11-19 and 10% between August 26 and September 2.

(Insert Figure 3 here: 1-month Forward Premium)

The movement of the 3-month forward premium is basically identical to that of the 1-month forward premium. The only difference is that the amplitude of the fluctuation of the 3-month premium was smaller than that of the 1-month premium. That is perhaps not surprising given the known analytical results obtained in the literature about the term structure of forward premia (see Bartolini and Bodnar (1992)) or interest rate differentials corresponding to different maturities (see Ozkan and Sutherland (1998) and Svensson (1991)). These results have indicated that the short-term risk premium and interest differential experiences greater fluctuation than their longer-term counterparts.

Given the above results on term structure of forward premium, one would expect the 6-month and 12-month forward premia to experience less fluctuation than their 3-month counterpart. However, that was the case only before the Hong Kong dollar came under serious attack in October 1997. A careful comparison of the forward premia since the middle of November 1997 shows that the 6-month forward premium more often than not exceeded the 3-month premium, and the 12-month premium in turn was above the 6-month premium throughout much of the same period. (See Figure 4 for a comparison of the 3-month and 12-month forward premia.) Thus, the evidence suggests that the market was more concerned about the Hong Kong dollar peg's collapse in the long run than in the short run. That is consistent with surveys of fund managers, many of whom believed that that the peg would go in one or two years even though it was not in immediate danger.

(Insert Figure 4 here: 3- and 12-month Forward Premia)

In response to renewed attacks on the Hong Kong dollar and selling pressure on the Hang Seng stock futures index, the HKMA, on behalf of the Hong Kong SAR government, started to purchase blue chips on the stock market in the middle of August 1998 to push up the Hang Seng index for that month. Even though the HKMA intervened regularly in the foreign exchange market, the intervention in the stock market was extraordinary, and the government in the process spent about US$15 billion on the stocks. A discussion of the circumstances under which the government took such an unprecedented action can be found in Lui, Cheng and Kwan (1999). It suffices to say that any alleged need for direct intervention in the stock market could not be dissociated from the government's failure to close some obvious loopholes in Hong Kong's currency board mechanism. The most important loophole was the small Aggregate Balance of the banking system for the purpose of settling their transactions. Until September 1998, the loophole allowed speculators to push up HIBOR sky high by selling about HK$2 billion of Hong Kong dollars in the spot market.

After the stock market intervention in the second half of August 1998, the HKMA announced on September 5 "seven technical measures" to strengthen Hong Kong's currency board system against currency speculation. More than technical, these 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. As far as the mechanics is concerned, the new measures explicitly established a discount window to replace its predecessor the "Liquidity Adjustment Facility."[5] The Aggregate Balance for clearing purposes is enlarged many-fold because banks would be able to borrow from the HKMA through the discount window at known discount rates.[6] In addition, it provided an explicit "undertaking" of

[5] The Liquidity Adjustment Facility was first established in June 1992.

[6] According to HKMA's web page, the Aggregate Balance before discount window on December 23, 1998 was HK$2.581 billion and the outstanding Exchange Fund Bills and Notes amounted to HK$97.45 billion.

the convertibility of Hong Kong dollars in the banks' balances with the HKMA at the rate of 7.75.

The 1-month premium dropped precipitously from 10% on September 2, 1998 to 3.3% on the next day as the battle between the HKMA and "market manipulators" (and many ordinary investors) came to a temporary halt. Both HIBOR and the forward premium remained low after the "seven measures" had been introduced. However, due to a concern over the duration of HKMA's commitment to the convertibility undertaking, and upon HKMA's chief executive's suggestion on Monday, September 14, that the undertaking would be changed from 7.75 to 7.8 (the official parity under the currency board) as soon as possible, the market was nervous and HK$9.3 billion was sold for U.S. dollars during the day.[7] The forward premium went up by almost 2% on that day.[8] To calm the market, the HKMA announced in the afternoon of that day that it was committed to the rate of 7.75 for at least six months. The 1-month HIBOR dropped from its intra-day high of 12.25% to close at 8% and the 3-month HIBOR dropped from its intra-day high of 11.75% to close at 9.375%.[9]

Both the "seven measures" introduced by the HKMA on September 5 and the "eighth measure" forced upon it in the afternoon of September 14 were interesting experiments on the impact of government policy. Both showed the importance of confidence in the peg to market behavior and the importance of the government's commitment to the peg by way of actual actions (after the convertibility undertaking of the HKMA was given a clear duration and acquired the legal force of a contract) to the confidence in the peg.[10] The establishment of a new discount window that provides

---

Since these bills and notes can be used for the discount window as collateral, the Aggregate Balance can be enlarged by a maximum of 39 times.

[7] According to Xie and Yam (1998, p.21) HK$1.6 billion was bought back on September 15, HK$7.5 billion on September 16, and HK$1.3 billion on September 17. That is to say, the inter-bank Hong Kong dollar liquidity was increased by HK$1.1 billion after uncertainty about the HKMA's commitment was resolved.

[8] The 3-month and 6-month forward premia went up by 1% and 0.5% higher, respectively. However, as a reflection of the intra-day HIBOR to be reported below, the intra-day forward premia were higher.

[9] Sing Tao Daily, September 16, 1998.

[10] See Lui, Cheng and Kwan (1999) for a more detailed discussion.

greater liquidity to the banks than its predecessor was useful in calming concerns about interest rate fluctuations in the face of currency speculation. However, the legal and contractual guarantee of the exchange rate to the banks was most crucial to confidence in the peg itself. Without such a guarantee, the scope and power of both exchange rate and interest rate arbitrage would be severely limited.

III. Is the Linked Exchange Rate a Credible Target Zone

How credible was the peg? We see the actual operation of the peg as no different from a target zone exchange rate system even though its currency board arrangement has imposed strict discipline on money supply.[11] Our strategy is to infer from financial market data the perceived credibility of the peg across major policy regimes. Regime 1 (1983:11:1 – 1992:3:31) is called the "rule-bound" period because at that time, the HKMA was passive and relied mainly on rules in policy-making. Regime 2 (1992:4:1 – 1998:9:6) can be interpreted as the "discretion" period. During this time, the HKMA had already acquired most of the intervention tools (new accounting arrangements, Exchange Fund bills and notes, LAF, etc.) and become more and more proactive. Notably, the level shift in the spot rate (see Figure 1), or the so-called second line of defense strategy, also started roughly from the beginning of this period. Regime 3 (1998:9:7 – present) refers to the period after implementing the seven technical measures, a period during which the HKMA reverted back to rules as its operating principles.

We can extract from the forward premium data the implicit risk of devaluation as perceived by the foreign exchange market, using the drift adjustment method developed in the target zone literature. Given the devaluation risk, we can calculate the implicit probability of devaluation conditional on a given size of realignment. Let s_t and c_t be the natural logarithms of the spot exchange rate and the central parity, respectively. Then one can write down an identity $s_t \equiv c_t + x_t$, where x_t is by construction the spot rate's (log) deviation from the central parity. Write $\Delta c_{t+\tau} = c_{t+\tau} - c_t$ and the average rate of realignment from time t to $t + \tau$ as $\Delta c_{t+\tau}/\tau dt$, and similarly for s_t and x_t. It follows from the identity that

[11] Leung (1996) studies the Linked Exchange Rate system from the point of view of a target zone model using data up to 1993.

$$E_t \Delta c_{t+\tau} / \tau dt \equiv E_t \Delta s_{t+\tau} / \tau dt - E_t \Delta x_{t+\tau} / \tau dt \qquad (1)$$

The left-hand-side in (1) is the implicit risk of devaluation (revaluation if negative) as perceived by the foreign exchange market. The two expected rates on the right-hand-side can be recovered from observed data. First, we identify the expected rate of total depreciation, $E_t\Delta s_{t+\tau}/\tau dt$, with the observed forward premium by appealing to covered interest parity. Second, the expected rate of drift within the target zone, $E_t\Delta x_{t+\tau}/\tau dt$, is estimated by the linear projection of $\Delta x_{t+\tau}/\tau dt$ on a vector of state variables z_t, with the projection standard errors computed from a Newey-West heteroskedasticity-autocorrelation consistent matrix of τ lags:

$$\Delta x_{t+\tau} / \tau dt = z_t' \beta + \varepsilon_{t+\tau} \qquad (2)$$

The state variable vector z_t includes an orthogonal cubic polynomial in x_t, the current forward premium of maturity τ, and a measure of the slope of the yield curve (the difference between 12-month and 1-month forward premium). Our choice of state variables is based on the theoretical target zone literature. Svensson (1991) shows that the expected rate of drift is a negatively sloped, nonlinear function of x_t, a well known property of a credible target zone (Krugman, 1991). We specify a cubic polynomial to capture the possible nonlinearity. The use of orthogonal polynomials, as opposed to simple polynomials, lessens the extent of multicollinearity in the empirical estimation. The remaining two state variables are meant to capture the influence of stochastic devaluation risk on expected exchange rate movements, an extension of the basic target zone model suggested by Bertola and Svensson (1993). As in previous literature (e.g., Lindberg et al (1993, 1994), Rose and Svensson (1994), and Svensson (1993)), we include the forward premium or the domestic and foreign interest rate differential as a state variable. In addition, we follow Bekaert and Gray's (1998) empirical target zone model by including the forward premium counterpart of the slope of the yield curve to capture the temporal profile of devaluation risk.

The projection equation (2) is run separately for the three policy regimes for the 1-month and 3-month horizons. We use three different central parity rates, 7.8, 7.74 and 7.75, to construct the x_t series, corresponding to the three policy regimes. The level shift from 7.8 to 7.74 is to reflect the second line of defense strategy of the HKMA during regime 2 (see Figure 1), whereas 7.75 is the guaranteed exchange rate covered by the convertibility undertaking commitment. Chow tests indicate that there have been significant structural changes across the three regimes, which provides empirical support to our 3-regime demarcation scheme. Other than providing an estimate of the expected drift, the projection equations are of interest in their own right. The estimation results reported in Tables 1 and 2 lead to the following conclusions.

(Insert Tables 1 and 2 here: Projection Equations --- 1-month and 3-month.)

First, consider the marginal relationship between the expected drift and the current exchange rate position x_t. In all the linear specifications in which the quadratic and cubic term are excluded, the x_t coefficients are statistically significant and negative, implying that exchange rate movements are mean-reverting within the target zone, holding constant the level of devaluation risk proxied by the two remaining state variables. We have also found that omitting the two devaluation risk proxies from the regression weakens the mean-reverting property considerably. Taken together our empirical finding supports the Bertola and Svensson (1993) model with exogenous stochastic devaluation risk which shifts up and down the negative relationship between the expected drift and x_t.

The evidence for nonlinear mean-reverting, a property emphasized in the Krugman (1991) fully credible target zone model, is mixed, however. Nonlinear mean-reverting shows up in regimes 1 and 3 in the 1-month case, and also in regime 3 in the 3-month case, as indicated by the small p-values of Wald tests reported in row "exclude P_2 and P_3". Moreover, the sign pattern of the polynomial coefficients indicates that the nonlinearity is not necessarily of the famous S-shaped ("smooth pasting" property) suggested in fully credible target zone models.

Finally, the coefficients of the two devaluation risk proxies – current forward premium and yield curve slope -- exhibit a pattern of cyclical sign reversal across regimes. In regime 1, the two coefficients are significantly negative, suggesting that during the rule-bound period, the automatic adjustment mechanism worked well and the peg was most credible. The two coefficients become significantly positive in regime 2, which signals the absence of interest arbitrage and lack of credibility. Contrary to its own belief, the HKMA had in fact made the currency board less credible, after acquiring all the intervention tools during the discretion period. In regime 3, the two coefficients revert back to the negative zone in most cases, indicating that the board had regained credibility after returning to a rule-bound regime.

The transition from the rule-based regime 1 to the discretionary regime 2 was a gradual process. We have argued that it is more reasonable to choose 1992, rather than 1988, as the demarcation line between the two regimes. To test the robustness of the empirical results, we have also performed the same econometric analysis reported in Tables 1 and 2 on data based on having 1988 as the dividing line. The general results remain the same, although there is some slight weakening of statistical significance.[12]

(Insert Figures 5 – 8 here: Devaluation risk).

Figure 5 depicts the estimated 1-month devaluation risk together with 2-standard deviation confidence bands for regime 1. The devaluation risk is statistically significant at the 5% level if zero lies outside of the bands. We see that for most of the time the devaluation risk was not significant, except a few short intervals during which the devaluation risk was significantly different from zero. This shows that the peg was in general credible in the rule-bound regime. In Figure 6, we see that the peg had been under occasional devaluation pressure even before the currency crisis period. The crisis period was dramatized by the skyrocketing devaluation risk unseen before, as can be seen in Figures 6 and 7. The rapid recovery of credibility after a return to a rule-based currency board in regime 3 was equally dramatic (Figure 8): the devaluation risk dropped by half

[12] For lack of space, we do not report details of these results, which are available upon request.

overnight after the announcement in 5 September 1998, and then gradually became insignificant.

The last result can be interpreted from another perspective. During the financial crisis, many people believed that there was a so-called "Asian risk premium" because Hong Kong was regarded part of a troubled region. The dramatic restoration of market confidence in the peg after the return to the rule-based system is not supportive of this assertion. Had a general Asian risk premium existed in Hong Kong, we could hardly witness its disappearance in a matter of just a few days, after the announcement of a new policy. Even if one insists on the existence of such a premium in Hong Kong, the evidence in Figure 8 can at most allow us to make two different but related interpretations. First, the Asian risk premium was not significant in Hong Kong. Second, Hong Kong could be easily differentiated from the rest of Asia if the HKMA had chosen the rule-based approach.

One may also argue that the dramatic restoration of confidence is merely a happy coincidence with the improvement in the external environment -- the Asian situation may have just happened to be stabilized around that time. Improvement in the external environment no doubt had played a role, but it should have influenced the low frequency components of the devaluation risk series rather than its high frequency, day-to-day movements. It would be too much a coincidence to see the precipitous drop in devaluation risk on the first trading day (Monday, September 7) right after the announcement of the seven technical measures on Saturday, September 5, 1998. The episode from September 13 to 15 -- the initial ambiguity of the guarantee period covered by the Convertibility Undertaking and its subsequent clarification -- shows up in Figure 8 as the small spike after the dividing line of September 7. The exact timing and the high frequency nature of the movements clearly speak against the coincidence hypothesis.

Given an estimate of the devaluation risk, we can recover the implicit probability of devaluation perceived by the market. Let p_t^{τ} be the probability at time t of a realignment of random size $\Delta c_{t+\tau}$ during the period from time t to $t + \tau$. The expected change in central parity (expected devaluation) can be written as

$$E_t[\Delta c_{t+\tau}] = (1 - p_t^{\tau})0 + p_t^{\tau} E_t[\Delta c_{t+\tau} \mid realignment]$$
$$= p_t^{\tau} E_t[\Delta c_{t+\tau} \mid realignment] \quad (3)$$

In terms of rate of changes, (3) can be rewritten as

$$E_t[\Delta c_{t+\tau}] / \tau dt = \nu_t^{\tau} E_t[\Delta c_{t+\tau} \mid realignment] \quad (4)$$

where $\nu_t^{\tau} \equiv p_t^{\tau}/\tau dt$ is by definition the expected average frequency of realignment during the period from time t to t + τ. To illustrate how the devaluation probability can be calculated, suppose that the 3-month devaluation risk is 7% and the expected devaluation size is 5%. In annual terms τdt = ¼ year. Using (4), ν_t^{τ} = 7/5 = 1.4, and p_t^{τ} = 1.4/4 = 0.35. Figure 9 shows the probabilities that the Hong Kong dollar would be devalued by 5% within one month and three months throughout the crisis period up to the end of our sample. As can be expected from theory, the probability of devaluation of the same magnitude within a given period is higher the longer the period. Among other things, the figure reveals that the probability of devaluation was highest during January 1998. For instance, the market's predicted probability that the Hong Kong dollar would devalue by 5% within three months was as high as 60%. An equivalent interpretation is that the probability of a 15% devaluation within three months would be 20%. Judged by the extent of devaluation by the New Taiwan dollar and Singapore's dollar around that time, a 10-20% chance of devaluation in three months was certainly not an unreasonable expectation.

In any event, regardless of the probable size of devaluation in the event of a de-pegging of the Hong Kong dollar, Figure 10 highlights the rapid drop in devaluation probability soon after regime 3 began. The following events are particularly revealing: the dramatic fall in probability after the announcement on 5 September about the new regime, the spike before the 14 September clarification of the convertibility undertaking, and the immediate calm down in market sentiments right after the clarification.

(Insert Figures 9 and 10 here: Devaluation Probability)

The relationship between forward premium and the current position of the exchange rate reveals further information about the credibility of a target zone. As shown by Bartolini and Bodnar (1992), the relationship can exhibit a variety of shapes depending on the monetary authority's credibility and her intervention policies. If the system is fully credible, then there must be a negative relationship between the forward premium and the deviation of the spot rate from its parity. Low credibility can invert the relationship into a positive one, and asymmetric credibility (i.e., the monetary authority is more credible in preventing appreciation than depreciation) can generate a bimodal pattern.

Figures 11 and 12 report scatter plots of 3-month forward premium against the spot exchange rate (as percentage deviation from parity). The smooth curve is obtained by fitting a fifth order orthogonal polynomial, which is flexible enough to accommodate the many shapes suggested by Bortolini and Bodnar (1992). The U-shape pattern in Figure 11 is mainly due to the data points of the first year (November 1983 to December 1984), which we highlight by triangles. This is the first year of the newly established currency board, during which the Sino-British negotiation over Hong Kong's future was in full swing and the market was understandably skeptical about the resolve of the monetary authority. After the first year the board started to accumulate credibility as indicated by the cloud of points in the Northwest and Southeast quadrants.

The bimodal curve in Figure 12 matches exactly the case of "Asymmetric Credibility, Discrete Intervention" analyzed by Bartolini and Bodnar (1992, figure 10, p.388). It can be seen that the hump in the Northeast quadrant is mainly due to observations of the crisis period (1 May 1997 to 5 September 1998), whereas the lower branch of the curve is due to the pre- and post- crisis observations. In other words, the crisis works like a natural experiment that provides the crucial observations for us to identify the complete curve including the upper branch in the Northeast quadrant. This empirical pattern suggests that the seeming stability of the discretion regime before the crisis (see Figures 1 and 6) was not the result of more intervention power as claimed by HKMA, but rather it was because the system had not yet been subject to a large enough shock.

(Insert Figures 11 and 12 here: Forward Premium vs. Spot Exchange Rate)

In conclusion, even before the Asian financial crisis, the peg was not regarded as fully credible by foreign exchange market participants. Against the background of the Asian financial crisis, confidence in the system suffered, indicating that the Hong Kong currency was not considered a safe haven for the turbulent Asia economies. Confidence in the peg was eroded further when the Hong Kong dollar came under attack by currency speculators. Fortunately, loopholes in Hong Kong's currency board system were plucked and a contractual commitment was made to the exchange rate. As a result, confidence in the peg was restored to the level that had prevailed before the Hong Kong dollar crisis. In other words, whatever the exact arrangement of the exchange rate system, be it a currency board or a target zone, confidence in the exchange rate cannot be taken for granted.

IV. Relationship between Perceived Risks and Negative Fundamentals

An interesting question about the Asian financial crisis in general and the Hong Kong dollar crisis in particular is whether or the extent to which they were caused by a deterioration of their fundamental economic factors. If they were not caused by fundamentals, then some sort of systemic failures such as contagion effect may be responsible. In this section, we examine four fundamental variables whose deterioration is widely regarded as conducive to currency crisis.

First, let us look at Hong Kong's real exchange rate index to see if deterioration in its international competitiveness could have contributed to the crisis. The real exchange rate is obtained as a weighted average of the bilateral real exchange rates of Hong Kong vis-à-vis its major trading partners. Real exchange rate is defined as nominal exchange rate adjusted for relative inflation, and the weights are their respective shares of Hong Kong's domestic exports. The movement of the index of real exchange rate is depicted in Figure 13 with 1992 as the base year. Hong Kong has lost its international competitiveness throughout the entire period, but there were no dramatic changes in the

trend before or during the Hong Kong dollar crisis. In fact, the currency crisis occurred only after the Asian financial crisis had gained sufficient momentum.

The dotted line is obtained by ignoring China's official devaluation in January 1994. The rationale for this is that the 1994 devaluation merely allowed the official rate, which by 1994 governed only a small fraction of exports and imports in China, to move toward the market-based "swap rate" that was far more important in export and import decisions.[13]

Thus, there was no strong evidence to suggest that deterioration in Hong Kong's international competitiveness was a key contributing factor to the Hong Kong dollar crisis. Nevertheless, we cannot rule out the possibility that the accumulation of the deterioration of international competitiveness may have reached a threshold by October 1997.

(Insert Figure 13 here: Real Exchange Rate)

The real exchange rate index measures Hong Kong's international competitiveness in prices but not in quantities. As a supplement to the real exchange rate index, let us see how Hong Kong's trade balance developed over the relevant period. Trade balance is defined to be merchandise and service exports less merchandise and service imports. As Figure 14 has shown, Hong Kong's trade balance showed signs of decline since the third quarter of 1994. There was a deficit during the entire 1997 (which might reflect the cumulative effect of appreciation in the real exchange rate), and it might be a possible fundamental variable underlying the speculative attacks on the Hong Kong dollar.

(Insert Figure 14 here: Trade Balance)

Next consider foreign reserves, a variable whose reduction may contribute to exchange rate instability. Hong Kong's foreign reserves since 1991 are given in Table 3.

[13] Foreign exchange swap markets had been operating for many years in China before the government devalued its grossly over-valued "official" exchange rate to unify with the swap rate.

As can be seen, the foreign reserves continued to rise from the beginning of the period up to October 1997, when a major currency attack occurred. Thus, unlike other economies whose currencies were targets of speculation, there was no significant reduction in Hong Kong's foreign reserves at all. Quite to the contrary, Hong Kong's foreign reserves were rising. Even with a loss of some reserves between February and October of 1998, Hong Kong's foreign reserves ranked the third largest in the world, only after Japan and China at the end of November 1998.[14] Thus, changes in foreign reserves could not possibly be a factor behind the Hong Kong dollar crisis.

(Insert Table 3 here: Foreign Reserve)

Finally, let us examine the behavior of Hong Kong's unemployment rate, a variable that is often thought to be critical in the central banks' decision to devaluate their currencies in order to reduce the pain of unemployment. Hong Kong's unemployment figures are depicted in Figure 15. As is apparent from the figure, the unemployment rate in Hong Kong before the Hong Kong dollar crisis was low even by historical standard. Thus, there was no pressure from the employment front to suggest a devaluation of the Hong Kong dollar to reduce unemployment. Unemployment during the crisis did creep up continuously, but instead of being a cause for possible devaluation, it was a result of the credit crunch that followed the currency crisis. Thus, unemployment did not seem to be a significant contributor to the Hong Kong dollar crisis. If anything, it was one of the crisis' major casualties.

(Insert Figure 15 here: Unemployment Rate)

Needless to say, the above analysis is exploratory rather than conclusive. In order to formally test the hypothesis whether the Hong Kong dollar crisis was caused by deterioration in its economic fundamentals, or by bad policies, or due to the contagion effect, we need to develop a formal model for statistical testing.

[14] At the end of December 1998, Taiwan displaced Hong Kong as the third largest holder of foreign reserves at US$90,3 billion (see p.2 of Business Post, South China Morning Post, January 29, 1999).

V. Summary of Results and Directions for Further Research

In the above we showed how the risk premium of the Hong Kong dollar under the peg evolved from its inception in October 1983 to April 1999, and in particular how it has responded to changes in the global environment and Hong Kong's own exchange rate policy during the Asian financial crisis. Even before this crisis, the peg was not regarded as fully credible. During the crisis, confidence in the peg suffered, and eroded further after the peg came under speculative attacks. After measures were introduced by the HKMA to increase confidence in the peg and to enhance interest rate stability, confidence was restored to its earlier levels. The market responses have demonstrated quite convincingly that appropriate government measures were key in signaling the Hong Kong SAR government's commitment to the peg. In any event, with the accumulation of new "experimental" results from future crises, we would be able to gain additional understanding of their impact.

In Section III we calculated the probability of devaluation based on the forward premia by making alternative assumptions about the magnitude of devaluation. It seems that one direction of further research would be to estimate a stochastic process that governs both the timing and magnitude of devaluation by making use of the forward premia corresponding to the four different transaction times and the HIBOR-LIBOR differentials for maturities less than one month.

Another direction of further research would be to formulate a model suitable for Hong Kong's currency board system, including endogenous money supply (for example, as in Chan and Ngiam (1998)), the Aggregate Balance maintained by banks with the HKMA for clearing purposes under a "Real Time Gross Settlement" system, and the policy rules followed by the HKMA with regard to liquidity provision before the introduction of new measures in September 1998. It is conjectured that the exchange system featuring these elements would admit self-fulfilling crises. Statistical testing of such a model can help to answer the question as to whether and which of the four fundamental economic variables discussed in Section IV had contributed to the Hong Kong dollar crisis. More specifically, using the probability of devaluation we have obtained, we plan to estimate a structural model of speculative attack along the lines of Jeanne (1997).

References

Bartolini, Leonardo and Gordon M. Bodnar, "Target zones and forward rates in a model with repeated realignments," Journal of Monetary Economics, Vol. 30 (1992), 373-408.

Bekaert, Geert and Stephen F. Gray, "Target zones and exchange rates: An empirical investigation," Journal of International Economics, Vol. 45 (1998), 1-35.

Bertola, Giuseppe and Lars E. Svensson, "Stochastic devaluation risk and the empirical fit of target-zone models," Review of Economic Studies, Vol. 60 (July 1993), 689-712.

Chan, Alex W.H. and Naifu Chen, "An inter-temporal currency board," Pacific Economic Review, Vol. 4 (1999), 215-232.

Chan, Kenneth S. and Kee-Jin Ngiam, "Currency crises and the modified currency board system in Singapore," Pacific Economic Review, Vol. 3 (October 1998), 243-63.

Davis, Philip and Philip Rabinowitz, Methods of Numerical Integration, 2nd edition, New York: Academic Press (1994).

Jeanne, Olivier, "Are currency crises self-fulfilling? A test," Journal of International Economics, Vol. 43 (November 1997), 263-86.

Krugman, Paul, "Target zones and exchange rate dynamics," Quarterly Journal of Economics, Vol. 106 (1991), 669-682.

Leung, Wing-Fai, "Some characteristics of the Linked Exchange Rate System in Hong Kong," Hong Kong Economic papers, No. 24 (1996), 69-83.

Lindberg, Hans, Paul Soderlind and Lars E. Svensson, "Devaluation expectations: The Swedish Krona 1985-92," *Economic Journal*, Vol. 103 (1993), 1170-1179.

Lindberg, Hans and Paul Soderlind, "Testing the basic target zone model on Swedish data 1982 – 1990," *European Economic Review*, Vol. 38 (1994), p.1441-1469.

Lui, Francis T., Leonard K. Cheng and Yum K. Kwan, "An alternative approach to defending the Hong Kong dollar," Paper prepared for presentation in an AEA/CES joint session at the Allied Social Science Associations meetings in New York, January 3-5, 1999.

Ozkan, F. Gulcin and Alan Sutherland, "A currency crisis model with an optimising policymaker," Journal of International Economics, Vol. 44 (April 1998), 339-64.

Rose, Andrew K. and Lars E. Svensson, "European exchange rate credibility before the fall," European Economic Review, Vol. 38 (1994), 1185-1216.

Sachs, Jeffrey, Aaron Tornell and Andres Velasco, "The Mexican peso crisis: Sudden death or death foretold?" Journal of International Economics, Vol. 41 (November 1996), 265-83.

Svensson, Lars E., "The term structure of interest rate differentials in a target zone," Journal of Monetary Economics, Vol. 28 (1991), 87-116.

Svensson, Lars E., "Assessing target zone credibility: Mean reversion and devaluation expectations in the ERM, 1979-1992," European Economic Review, Vol. 37 (1993), 763-802.

Xie, Andy and Denise Yam, "Understanding the Hong Kong currency board," Morgan Stanley Dean Witter Memorandum, November 2, 1998.

Table 1: Projection equations (1-month)

	Regime 1		*Regime 2*		*Regime 3*	
constant	-0.4399	-0.1238	-0.7131	-0.9980	1.1060	1.1631
	(-2.3576)	(-0.2303)	(-4.3807)	(-3.6382)	(5.4595)	(4.9971)
$P_1(x)$	-4.1977	-6.1672	-1.5886	-2.2604	-0.7686	-0.8879
	(-4.8723)	(-5.7667)	(-5.9402)	(-4.0145)	(-7.5402)	(-10.289)
$P_2(x)$		0.7872		-0.8093		0.1629
		(0.6729)		(-1.5405)		(2.5795)
$P_3(x)$		-3.0409		-0.2892		-0.0270
		(-3.3173)		(-0.8976)		(-0.2489)
1-month forward	-0.8020	-0.8561	0.1606	0.1506	0.0164	0.0094
premium	(-3.4089)	(-3.6923)	(2.9684)	(2.6877)	(0.3829)	(0.2237)
Yield curve slope	-1.1507	-1.1677	0.2213	0.2097	-0.3803	-0.3854
	(-3.0927)	(-3.2887)	(2.5070)	(2.403)	(-3.2233)	(-2.9885)
R^2	0.17	0.20	0.24	0.25	0.58	0.58
exclude P_2 & P_3		[0.0014]		[0.2967]		[0.0070]
sample size	2174	2174	1656	1656	141	141

Table 2: Projection equations (3-month)

	Regime 1		*Regime 2*		*Regime 3*	
constant	-0.2782	0.1220	-0.4145	-0.5361	0.3110	0.3483
	(2.0050)	(0.7979)	(-4.2542)	(-6.4145)	(17.925)	(12.445)
$P_1(x)$	-2.3650	-1.9235	-0.9716	-1.2357	-0.2878	-0.2994
	(-6.0464)	(-5.0707)	(-5.5789)	(-8.4755)	(-39.782)	(-47.185)
$P_2(x)$		0.9354		-0.3293		0.0428
		(1.9154)		(-2.0863)		(4.0333)
$P_3(x)$		0.0137		-0.0698		0.0368
		(0.0277)		(-0.5068)		(1.5445)
3-month forward	-0.3402	-0.3739	0.0971	0.0938	-0.0258	-0.0326
premium	(-3.5188)	(-3.6723)	(4.5874)	(4.7023)	(-5.0853)	(-7.1933)
Yield curve slope	-0.2964	-0.3077	0.0651	0.0637	-0.0368	-0.0456
	(-2.4026)	(-2.5288)	(2.5309)	(2.5866)	(-3.1494)	(-3.5304)
R^2	0.29	0.30	0.43	0.44	0.89	0.91
exclude P_2 & P_3		[0.1496]		[0.1022]		[0.0001]
sample size	2131	2131	1613	1613	98	98

Notes to Tables 1 and 2:

1. T-values are in parentheses.
2. Dependent variable = $(x_{t+\tau} - x_t)/\tau dt$, $dt = 1/261$, $\tau = 22$ and 65 (business) days corresponding to 1-month and 3-month maturities, respectively. x_t = spot exchange rate (as percentage deviation from parity). Within a regime of T days, the dependent variable is defined for $t = 1, 2, \ldots, T-\tau$, i.e., the projection is strictly within regime.
3. Regime 1 = 1983:11:1 - 1992:3:31, Regime 2 = 1992:4:1 to 1998:9:6, and Regime 3 = 1998:9:7 to 1999:4:21, excluding holidays.
4. $P_1(x)$, $P_2(x)$ and $P_3(x)$ are Legendre orthogonal polynomials up to degree 3, with x rescaled to [-1, 1]. They are generated by the three-term recurrence relation: $(n+1)P_{n+1}(x) = (2n+1)xP_n(x) - nP_{n-1}(x)$, $P_0 = 1$, $P_1 = x$. See Davis and Rabinowitz (1984, p.34).
5. "Yield curve slope" is the differential between 12-month and 1-month forward premium.
6. "Exclude P_2 & P_3" reports the $\chi^2(2)$ p-values (in squared brackets) from Wald tests for the joint hypothesis of excluding $P_2(x)$ and $P_3(x)$. Evidence of non-linearity is indicated by a small p-value.
7. All equations are estimated by OLS with Newey-West covariance matrix of τ lags.

Table 3: Foreign Reserve (US$ million)

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*
Jan							65,864	80,333
Feb							63,813	78,637
Mar				46,405	52,418	58,062	63,395	78,512
Apr							63,558	77,643
May							66,629	77,893
Jun				47,121	53,633	57,308	67,622	77,858
Jul							66,071	77,844
Aug							69,516	73,408
Sep				47,274	51,762	55,375	71,441	69,300
Oct							73,992	69,400
Nov							79,133	88,600
Dec	28,889	35,250	43,013	49,277	55,424	63,840	75,341	89,600

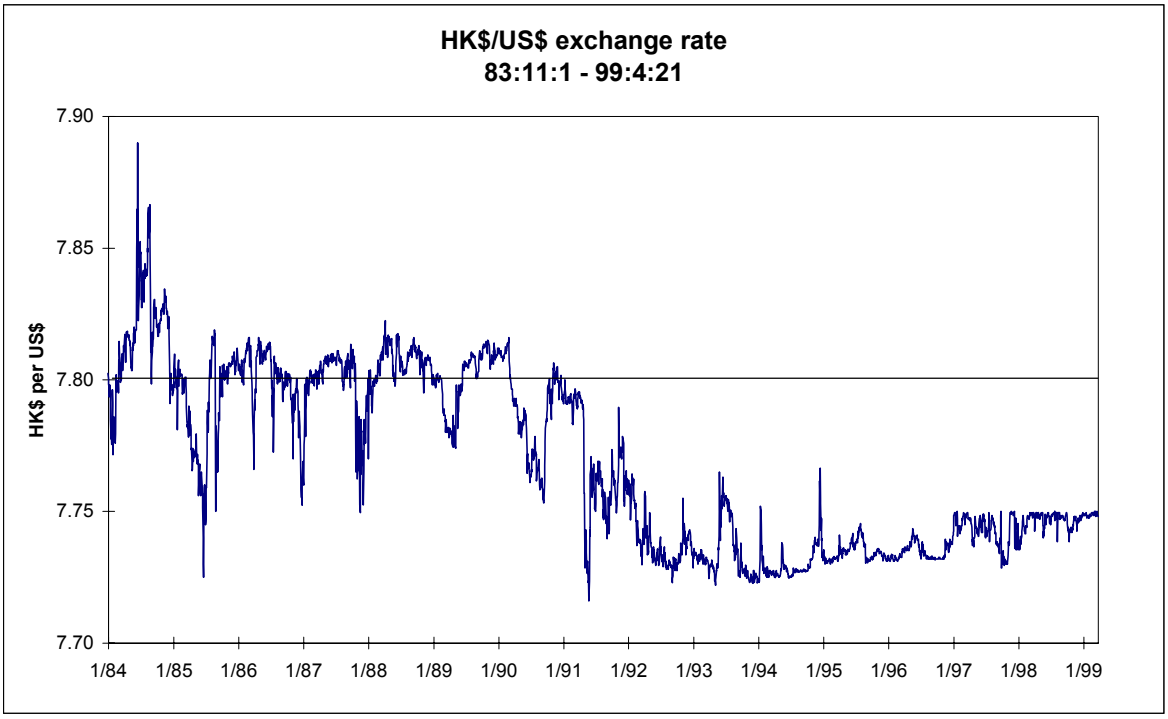

Figure 1: Spot exchange rate

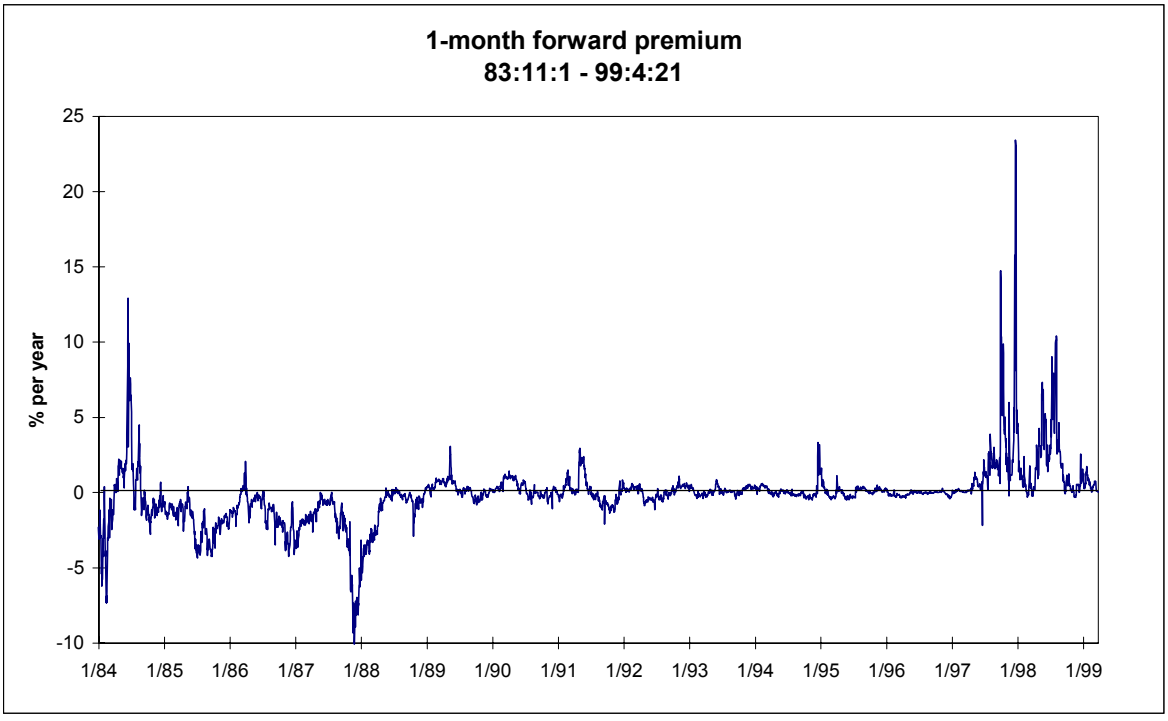

Figure 2: 1-month forward premium

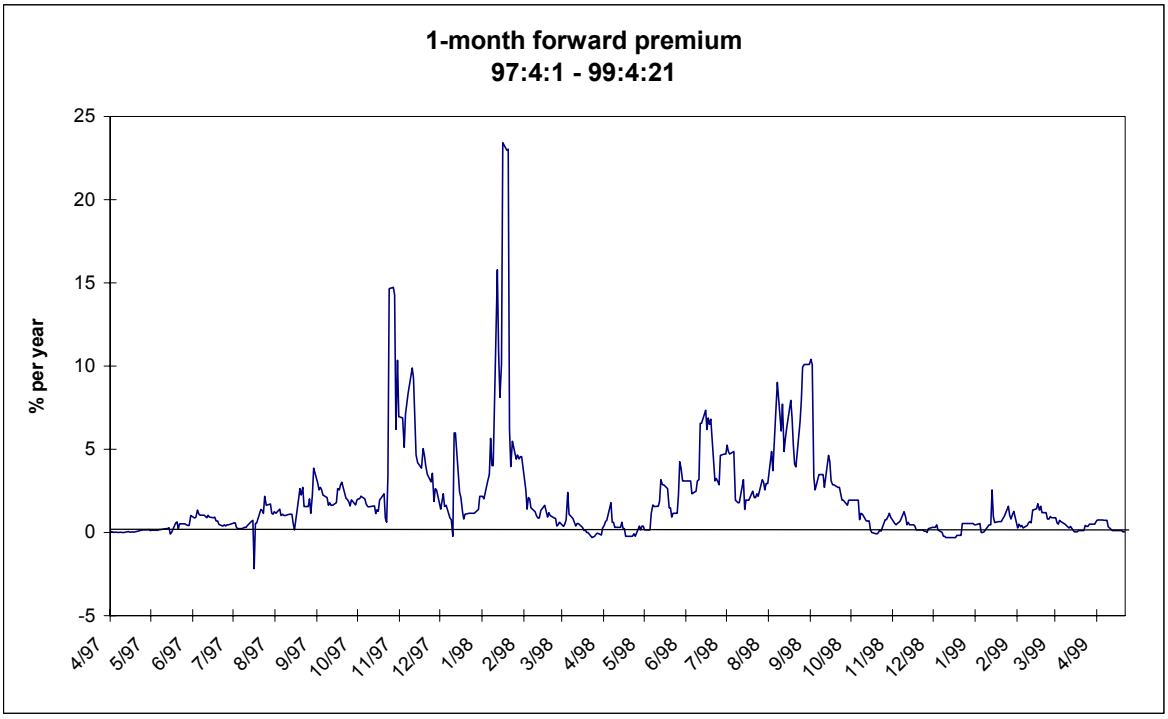

Figure 3: 1-month forward premium

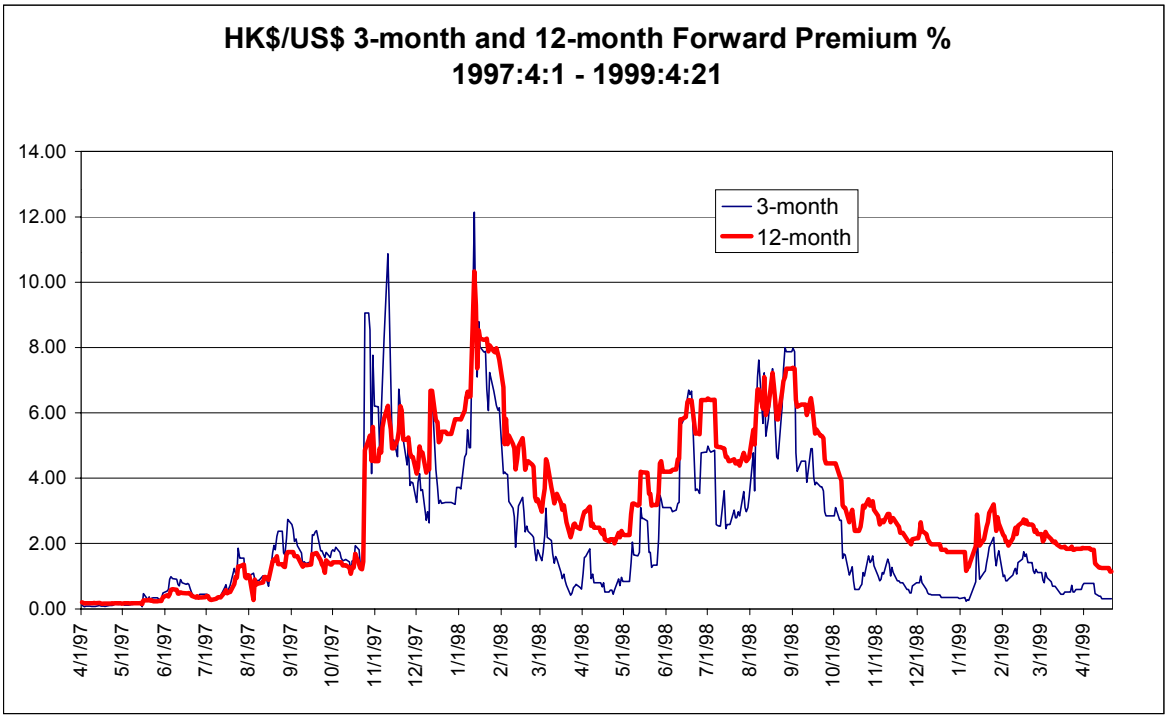

Figure 4: 3-month and 12-month forward premium

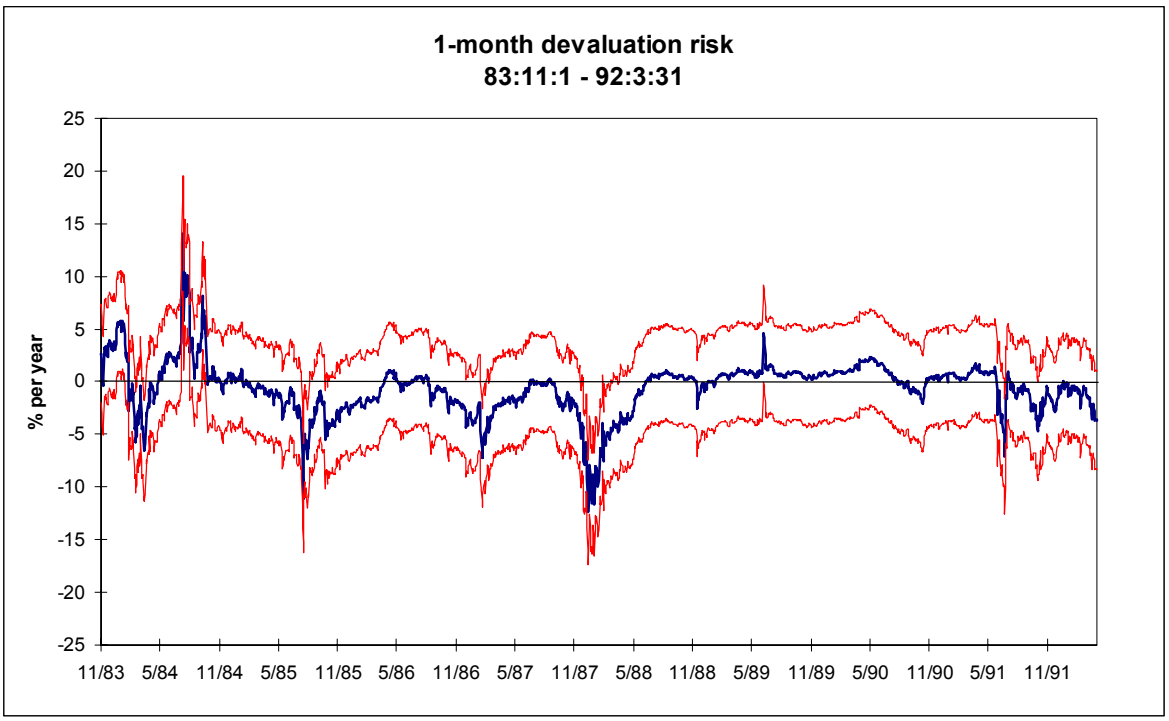

Figure 5: 1-month Devaluation risk and 2-standard deviation confidence bands

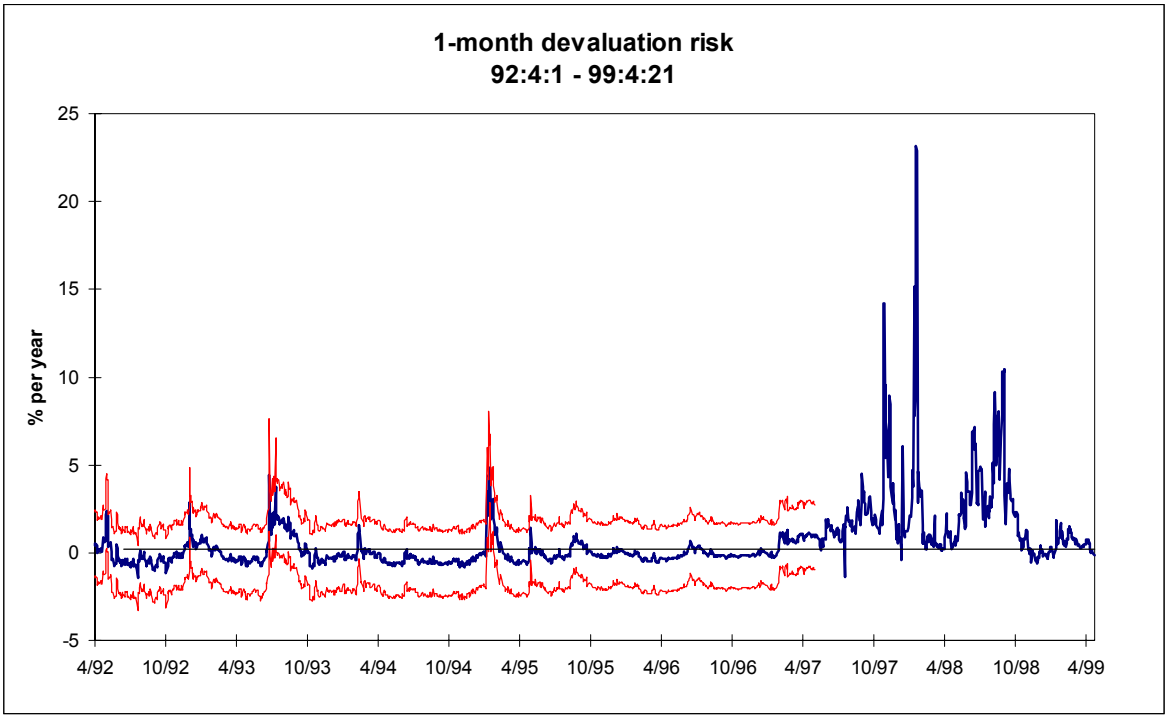

Figure 6: 1-month devaluation risk and 2-standard deviation confidence bands

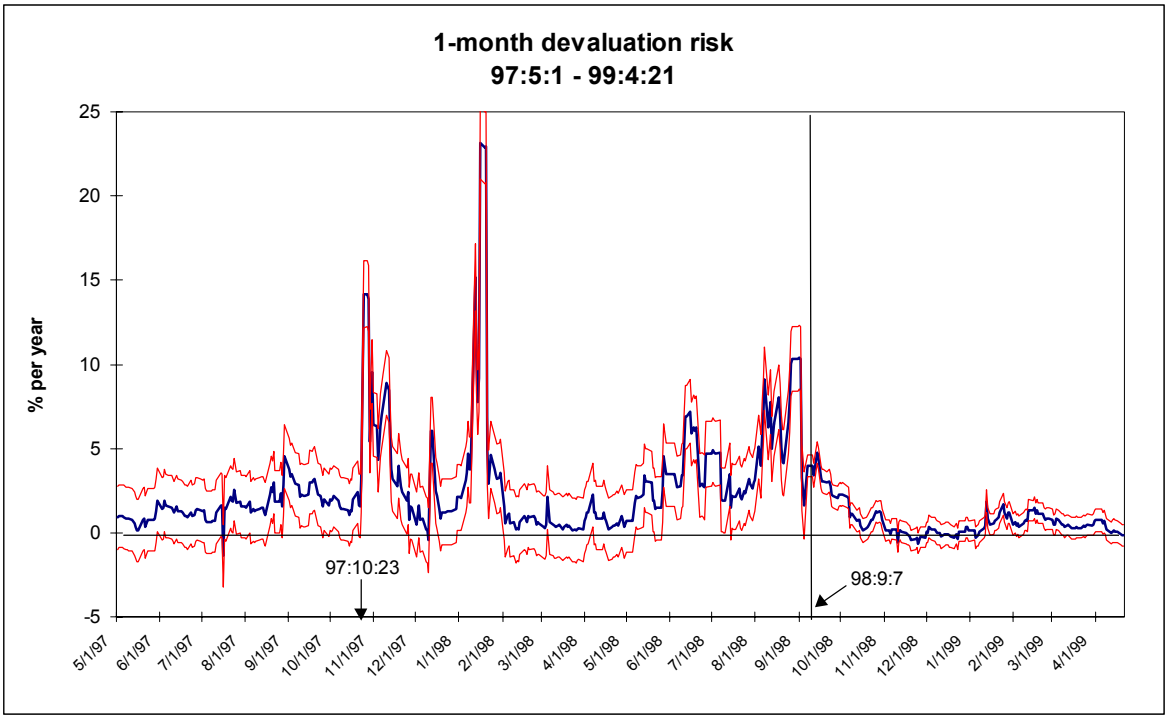

Figure 7: 1-month devaluation risk and 2-standard deviation confidence bands

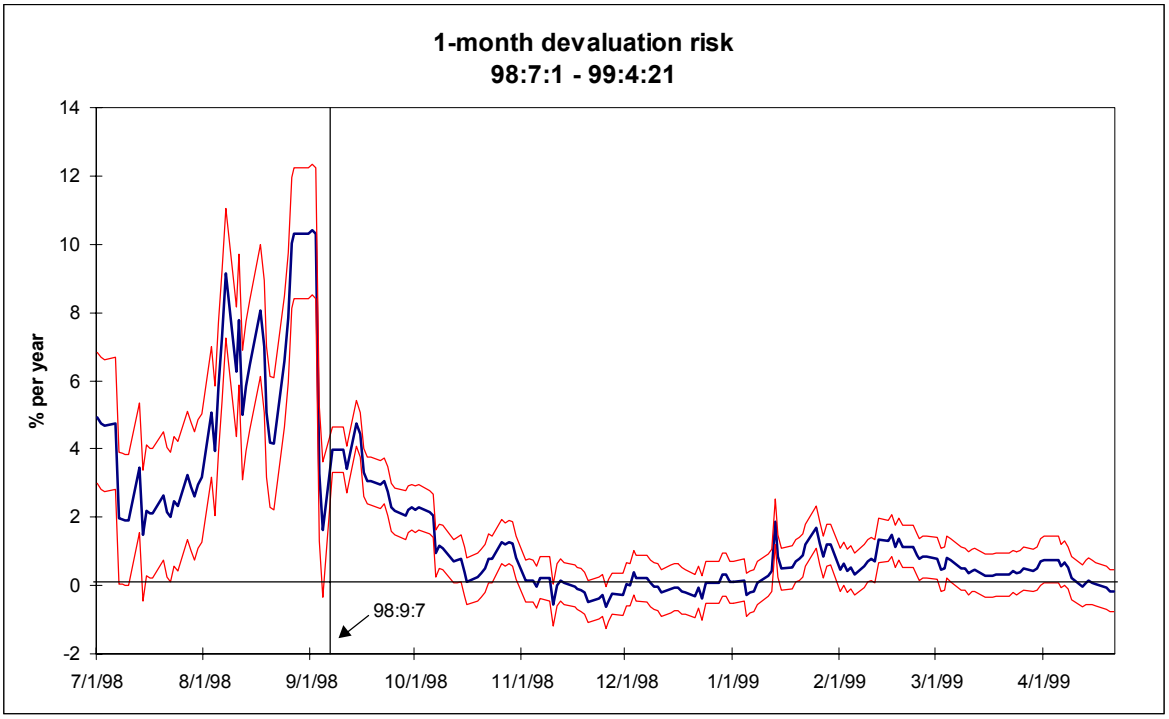

Figure 8: 1-month devaluation risk and 2-standard deviation confidence bands

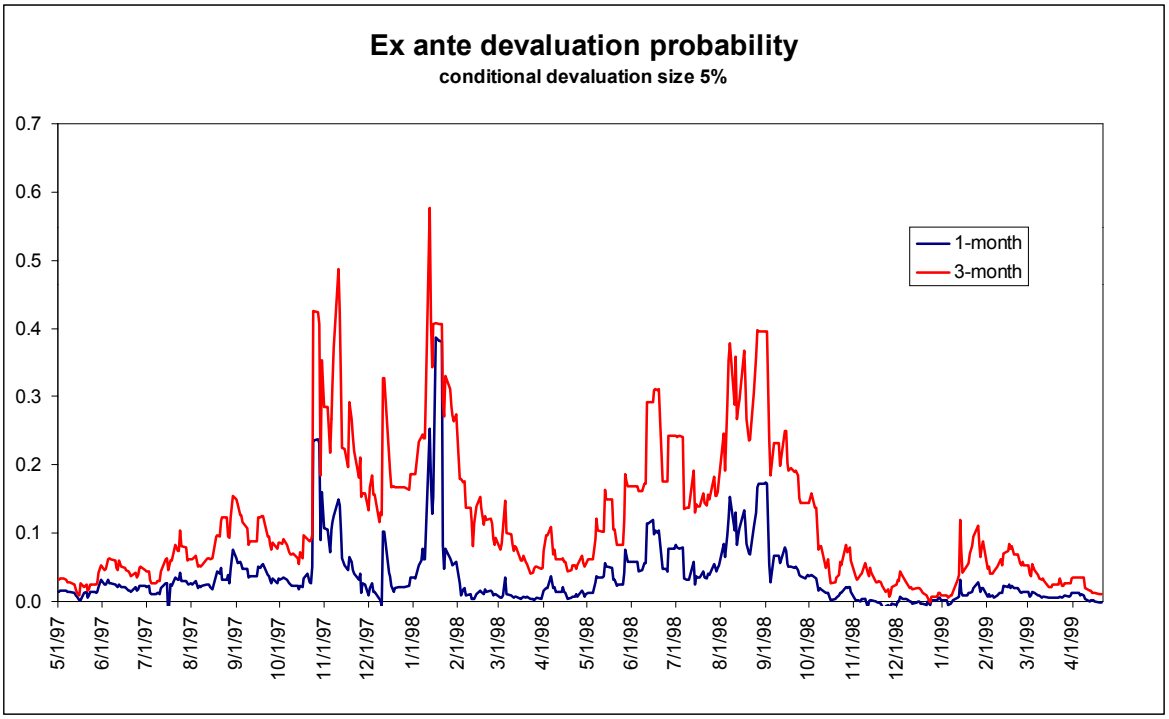

Figure 9: Devaluation probability

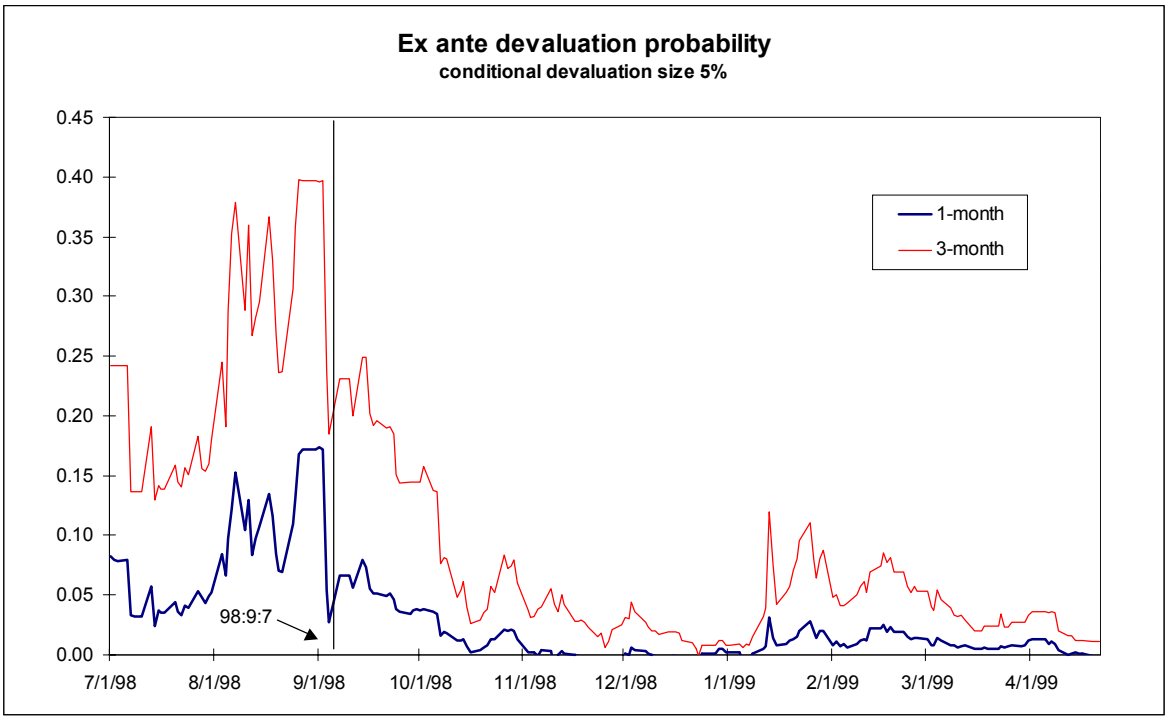

Figure 10: Devaluation probability

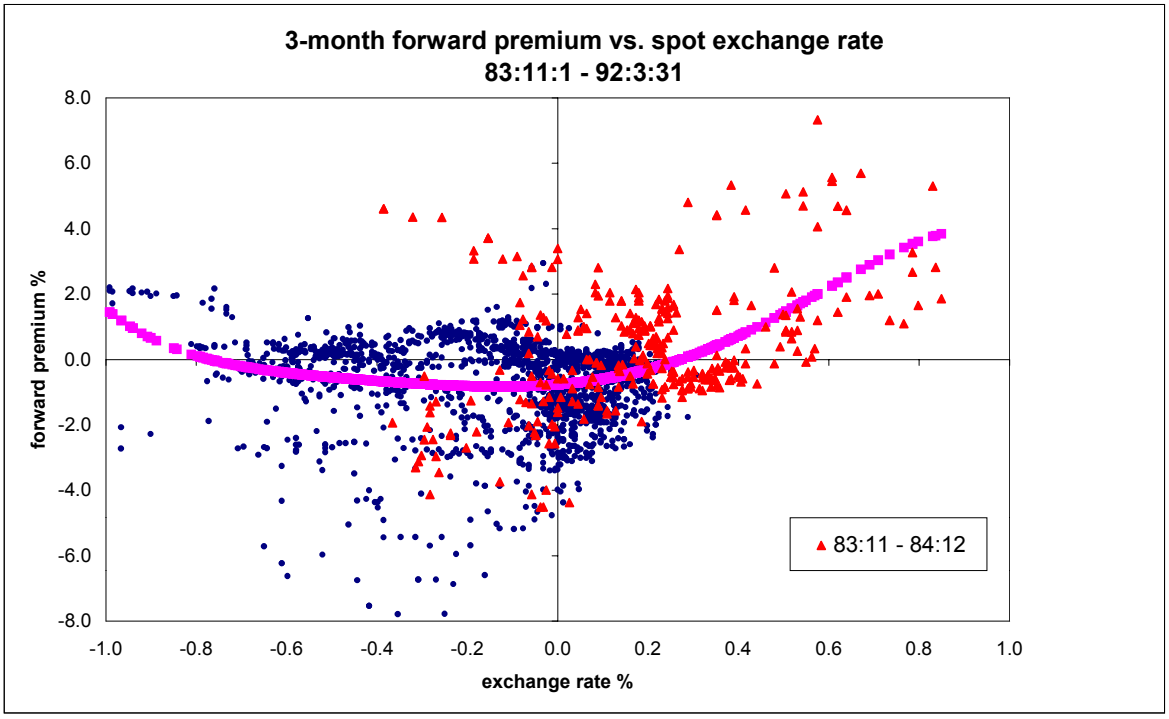

Figure 11: Forward premium and spot exchange rate

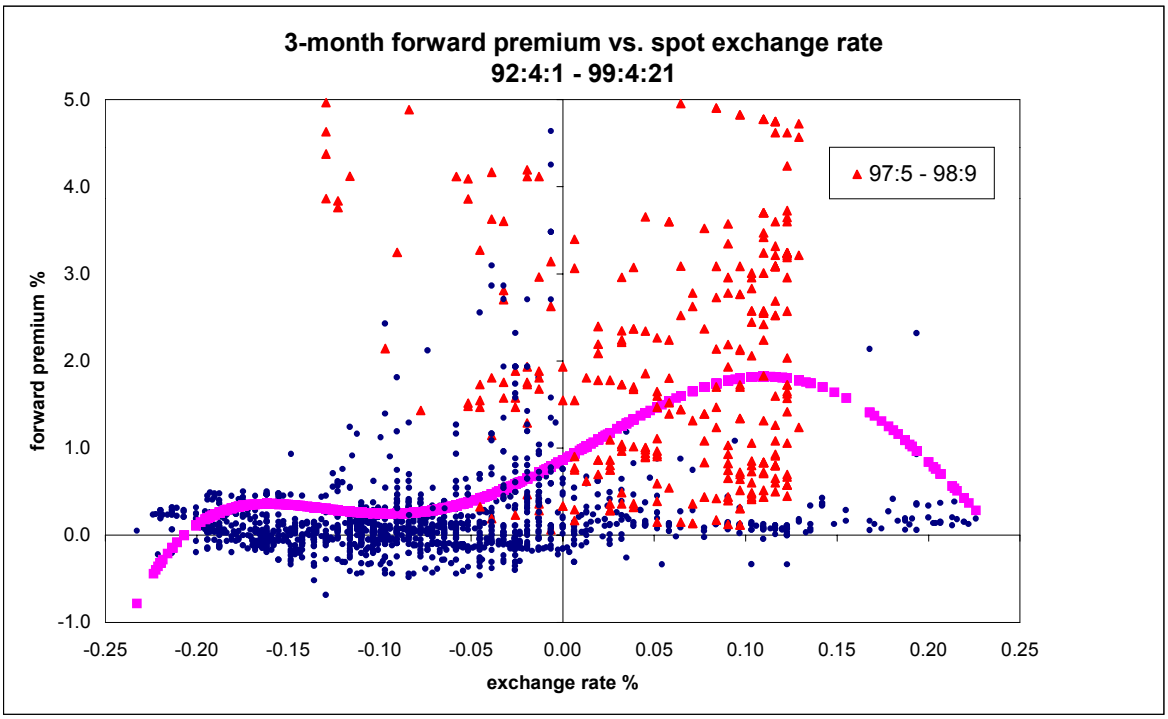

Figure 12: Forward premium and spot exchange rate

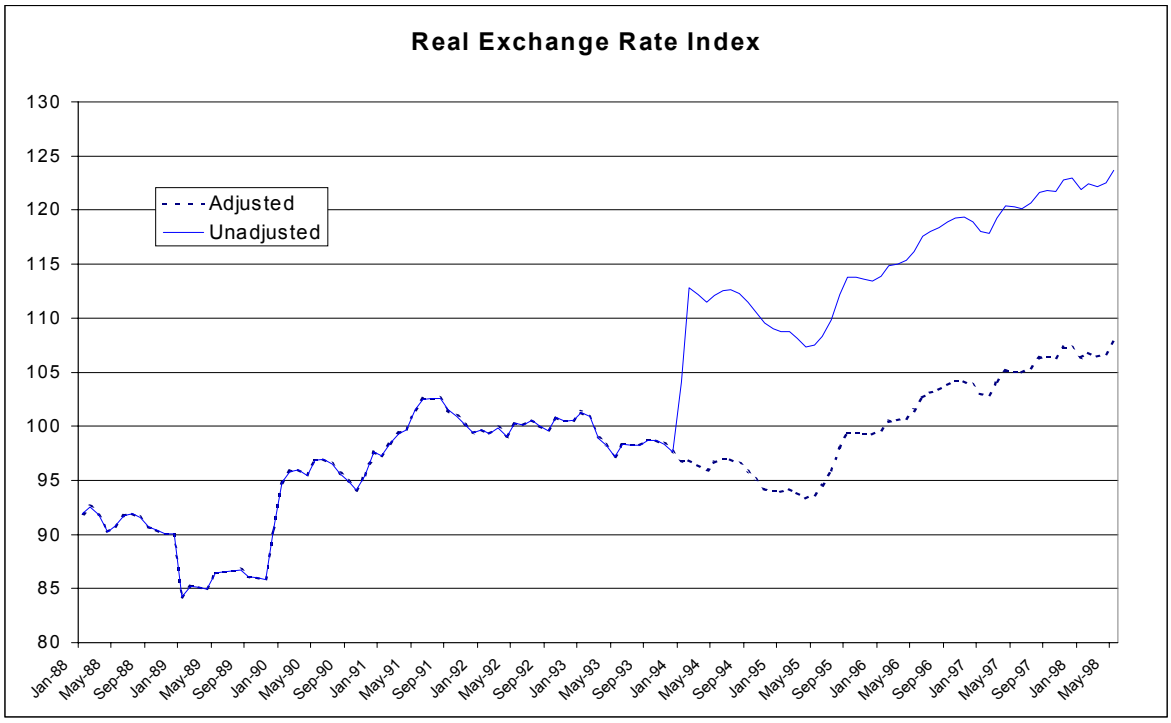

Figure 13: Real exchange rate

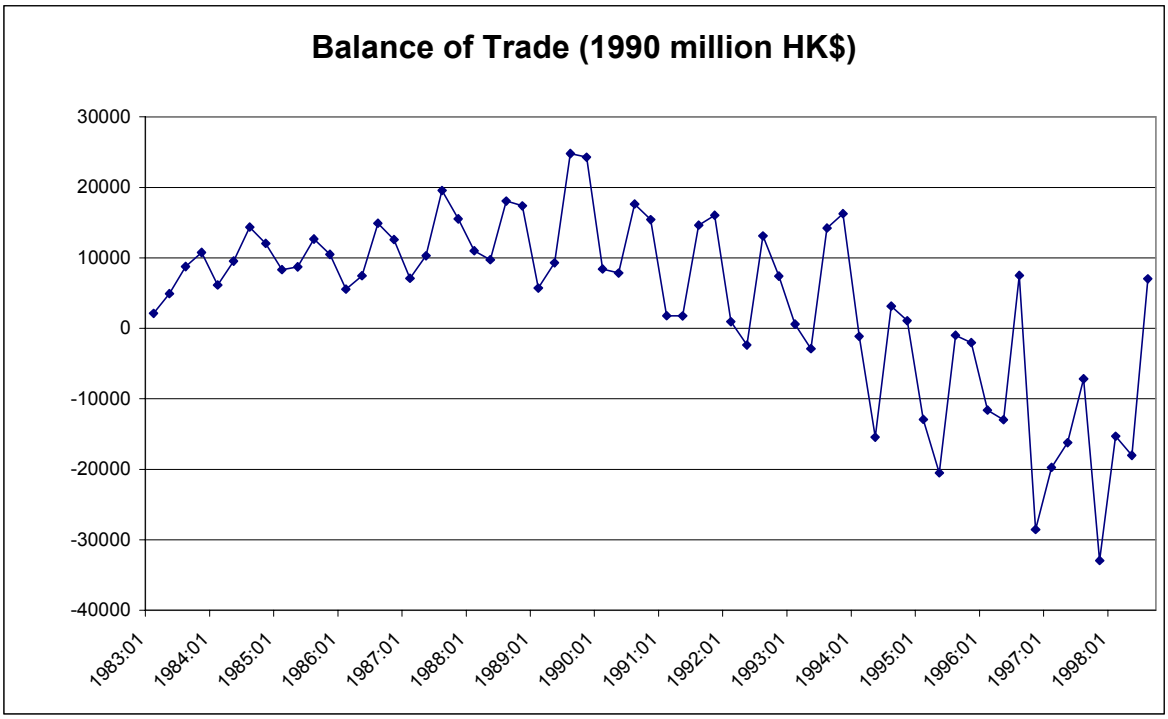

Figure 14: Balance of trade

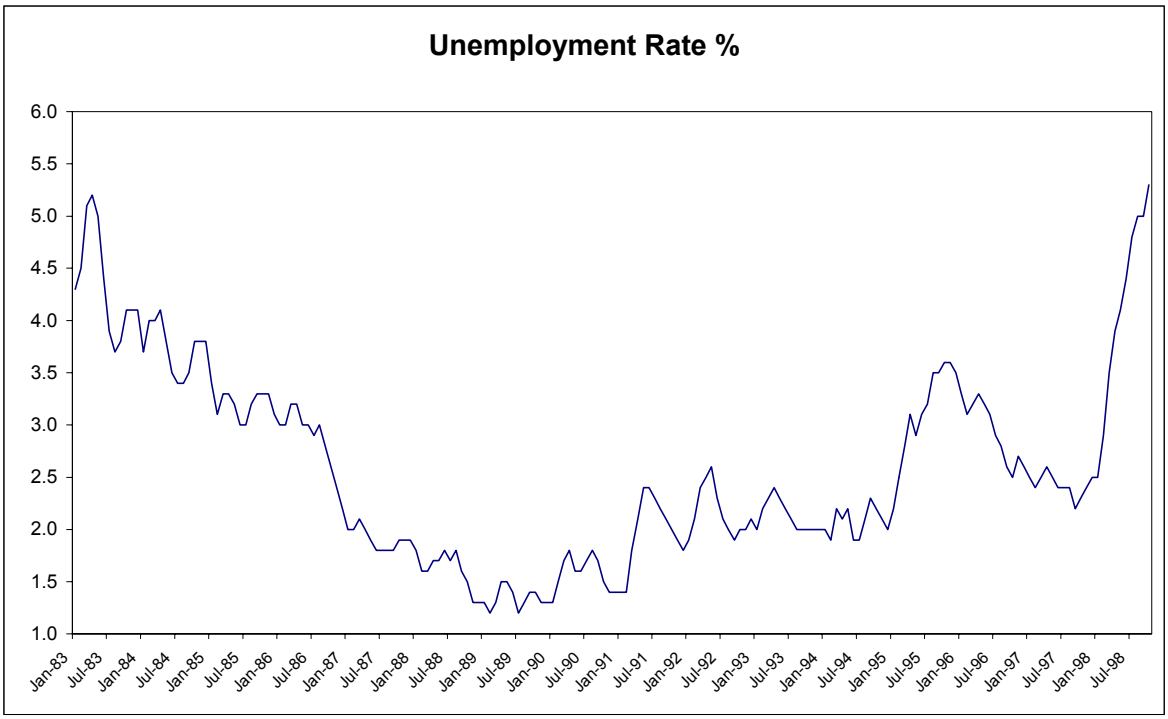

Figure 15: Unemployment rate