CREDIBILITY OF HONG KONG'S CURRENCY BOARD:

The Role of Institutional Arrangements*

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Abstract

The paper shows that Hong Kong's currency board in recent years has gone through three stages, a rule-bound regime, a regime based on discretion, and a return to fixed rules. A number of methods developed in the target zone literature have been used to measure the credibility of the system. The empirical results show that the currency board was most credible when the monetary authority adhered to fixed rules. Reliance on discretion contributed not only to the erosion of market confidence in the system, but also made speculative currency attacks during the Asian financial turmoil easier.

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1. Introduction

Since its introduction in Mauritius in 1849, currency board as a form of monetary institution has generally been neglected in the economics literature.[1] This is probably due to the fact that currency boards were adopted mainly in relatively small and unimportant economies. In recent years, the situation has changed. Argentina's re-adoption of the currency board in 1991 and the subsequent impressive economic growth records have contributed to its credibility as a useful monetary system. Its subsequent adoption in Estonia, Lithuania and Bulgaria indicates further its increasing popularity. Indeed, during the recent global financial turmoil, the currency board had been prescribed for the battered economies of Russia and Indonesia.

There may be another reason why the literature has not paid enough attention to the study of currency boards. Due to the lack of reasonably long and systematic data series, rigorous empirical analyses of their implications were difficult to conduct. Hong Kong, having a long history with the currency board, can readily fill in this gap. Its rich experiences include the abandoning and re-adoption of the currency board, and more importantly, it has gone through a series of subtle institutional changes and several episodes of speculative attacks on the Hong Kong dollar. Moreover, systematic data sufficient for implementing meaningful econometric analyses are available.[2] Properly studied, Hong Kong's experiences can offer useful insights for economies interested in the currency board.

The study of Hong Kong's experiences with the currency board is of theoretical interest in its own right. Stimulated by Kydland and Prescott (1977), there have been numerous studies on the relative merit of rules versus discretion in macroeconomic policies. Currency board, in its pure form, is a rule-based system. However, as we shall see in this paper, the Hong Kong Monetary Authority (HKMA), the *de facto* central bank of Hong Kong, had for some time been deviating from the rules by introducing a number of

[1] Among others, Schuler (1992), Hanke, Jonung and Schuler (1993), and Williamson (1995) are exceptions.

[2] See Kwan and Lui (1999) for an early attempt to implement econometric estimations of the implications of the currency board.

new tools of intervention. However, the greater reliance on discretion did not last indefinitely. Towards the end of the financial turmoil, it reverted to the rule-based system again. These changes have in effect created natural experiments for us to study the implications of rules versus discretion. The main objective of the paper is to test whether the currency board is more credible under the rule-based regimes or under the discretion regime.

The paper has four sections. The next section discusses the historical background of Hong Kong's currency board, with an emphasis on the events during the financial crisis. It shows that the currency board has gone through three regimes as demarcated by the choice of rules versus discretion. Section 3 develops and implements empirical tests on the credibility of the currency board under different regimes and interprets our findings. Section 4 discusses the effect of rules and discretion on the credibility of Hong Kong's currency board system from the point of view of delegation of functions and the incentive to intervene. The final section concludes.

2. An event analysis

In this section, we briefly outline the history of Hong Kong's currency board. As we shall see, it has hardly been an unchanging institution. In fact, from October 1983 to this day, the currency board has gone through three major phases: (a) a "rule-bound" regime; (b) a "discretion" regime, and (c) a de-emphasis of discretion and a return to a rule-based regime with a confidence booster. Our empirical analysis in the next section will demonstrate that the currency board's credibility varied significantly across regimes.

Hong Kong's first currency board was introduced in 1935 when the government decided to abandon the silver standard. From then to 1967, with the exception of four years of interruption during World War II, the Hong Kong dollar was pegged to the pound sterling at the rate of sixteen to one. Before issuing bank notes of sixteen HK dollars, the authorized note-issuing private banks were obligated to pay the Exchange Fund one pound to purchase the Certificate of Indebtedness (CI). The exchange rate appreciated over time to HK$14.55 per pound sterling by 1967. From 1972 to 1974, the

Hong Kong dollar was re-pegged to the US dollar. After the collapse of the Bretton Woods system, the government decided to let the currency float on November 25, 1974. However, the financial crises caused by anxieties over the future of Hong Kong led to great volatility and considerable downward pressure on the Hong Kong dollar. Eventually, on 17 October 1983, the government re-established the currency board system, but this time, the Hong Kong dollar was pegged to the US dollar at the fixed rate of 7.8. In other words, the government promised to buy bank notes at the rate of 7.8 per US dollar. Actual exchange rate in the market generally differed from the parity, however. The peg continues till this day.[3]

During the initial period after the re-establishment of the peg, the government by and large was following the fixed rules of the currency board passively. It fact, there is no evidence to suggest that the government was pursuing any active monetary policy at the time. A fundamental change in policy took place when the government began to initiate a series of institutional changes. In 1988 some new "Accounting Arrangements," which in effect made open market operations possible, were introduced. "Exchange Fund Bills" similar to short-term US Treasury bills have been issued since March 1990. A liquidity adjustment facility (LAF) was also opened in 1990 to provide liquidity to banks, and the HKMA was active in utilizing the LAF. With the new tools in hand, the HKMA acquired some central bank power to intervene in Hong Kong's money market.

The currency board is supposed to be a rule-based monetary system. The gradual "dilution" of the rules, as noted by Schwartz (1993), means greater reliance on discretion. The most significant case that illustrates the exercise of discretion is the change in HKMA's line of defense from 7.8 to 7.75. The official parity is 7.8, but the HKMA chose a "first-line defense" at 7.75, i.e., it would intervene at 7.75 instead of 7.8, to give it a greater sense of security. Figure 1 shows that beginning in around April 1992 the exchange rate could rarely move above the 7.75 level. However, this has created a new problem. Whenever the exchange rate went above 7.75, the market might fear that the HKMA would choose not to defend the peg. To restore confidence, the HKMA was

[3] For more details of the history of Hong Kong's currency board, see Nugee (1995) and Kwan and Lui (1999).

forced to intervene at 7.75. In a sense the HKMA has become the slave of its own discretion. The rationale for a first-line defense is also dubious. If the HKMA fails to maintain its defense of 7.75, it is doubtful that it will be able to maintain the ultimate defense of 7.8. An even more serious implication of greater reliance on discretion is the erosion of the public's belief that the HKMA will always keep the peg. Since it had significantly deviated from the passive rules of the currency board, there would be no guarantee that it would not abandon the peg altogether.

(Insert Figure 1 here: HK$/US$ exchange rate.)

One of our objectives is to test whether discretion is better than rules in strengthening the credibility of currency board. We use 1 April 1992 as a dividing line between a rule-bound regime ("regime 1") and a new regime in which active discretionary interventions were pursued ("regime 2"). The latter regime lasted up to 7 September 1998, from which time onwards there was a de-emphasis of discretion and a return to a rule-based regime with new rules ("regime 3").

The new rules mentioned above were adopted in the midst of the Asian financial turmoil. Up to early September 1998, the HKMA relied on interest rate arbitrage (the so-called "automatic adjustment mechanism") to defend the Hong Kong dollar. It posited that when there was capital outflow, the resulting drain in Hong Kong dollar liquidity would push up the latter's interest rate, which at a sufficiently high level would restore stability in the exchange rate by attracting capital to return. An interest rate hike was seen as a necessary evil in the defense of the Hong Kong dollar against speculation. Although the interest rate arbitrage seems to make intuitive sense, its ineffectiveness as a deliberate policy tool against currency speculation cannot be well understood without understanding the implications of the "real time gross settlement" (RTGS) system in conjunction with the HKMA's actions on October 23, 1997, which was known as "black Thursday" in Hong Kong.

On December 9, 1996, the HKMA introduced a new inter-bank payment system, the RTGS.[4] The "Aggregate Balance" of the banking system, which can be regarded as the lubricant for inter-bank settlements, was subject to what the HKMA regarded as an inescapable monetary rule of a currency board. Because the RTGS is very efficient, the aggregate balance typically stays at a low level of around, say, HK$ 2 billion. As the HKMA has recognized, the small size of the balance is conducive to high interest rate volatility. In other words, even a minor capital outflow can cause the interest rate to shoot up significantly under the said monetary rule. To illustrate the mechanics of how the interest rate goes up, we use the following example.

Suppose that the aggregate balance is equal to HK$ 2 billion, but there is a capital outflow of HK$ 3 billion. The banks' clients instruct the banks to sell this amount of HK dollar for, say, US dollar. If the US dollar cannot be purchased within the banking system, then the banks must buy from the HKMA. If a bank does not have enough money in its clearing balance for purchasing the US dollar ordered by its clients, it will have to borrow from the clearing balances of other banks. However, since the total outflow of capital exceeds the aggregate balance, the banks simply cannot settle their committed transactions, and thus, the interest rate may go up without limit. This is the case despite the banks' receipt of Hong Kong dollars from their clients' accounts. In fact, even Hong Kong dollar bank notes cannot be used to square their settlement accounts.

This process results from HKMA's deliberate adherence to what it had regarded as an essential monetary rule of a currency board. It believed that it was obliged to drain liquidity from Hong Kong's money market by the same amount as the capital outflow, and it chose to drain it directly from the aggregate balance that serves as the lubricant of the inter-bank settlement system. After buying HK dollars in the aggregate balance, the HKMA can delay the injection of HK dollar liquidity back into the system. In such a situation, the aggregate balance will shrink in size until the interest rate is squeezed up to such an extent that the banks would suffer a smaller loss by using their foreign currency to buy back the HK dollar from the HKMA to square their accounts. However, since these

[4] For details of the RTGS, see Hong Kong Monetary Authority (1998b).

Hong Kong dollars will not be delivered until one or two days later, the banks still need to borrow from the HKMA at any interest rate set by the latter for clearing purposes.

There was also a second kind of discretion that could raise the interest rate. In the morning of October 23, 1997, the HKMA surprisingly sent a memorandum to all the licensed banks in Hong Kong, warning them that they might have to pay penalty interest rate if they used the LAF repeatedly. Receiving this memo after several days of volatile interest rates, the banks began to panic. There were even rumors that the penalty rate could be as high as a thousand percent. The inter-bank interest rate shot up. At its peak, the rate was close to 300 percent.

Thus, the monetary system in Hong Kong was such that interest rate was very sensitive to capital flows. In addition, the HKMA might choose to magnify interest rate volatility through various kinds of discretionary measures. Until early September in 1998, the HKMA's policy making was guided by a belief that high interest was a necessary instrument for dealing with speculative attacks against the Hong Kong dollar. Moreover, a reduction in interest rate volatility was seen as incompatible with the goal of exchange rate stability. It was only after severe public criticisms and heavy market pressure during the financial crisis that the HKMA gradually abandoned its high interest rate defense strategy. There are several reasons for the change in its position.

First, high interest rate was no longer an effective way to deter or punish speculators. Knowing that a small run on the Hong Kong dollar could trigger the monetary mechanism to push up the interest rate, which could be further amplified by the discretion of the HKMA, speculators could either short the Hong Kong dollar forward or short the stock futures index before launching an attack on the spot market of the Hong Kong dollar. Losses in the spot market could easily be outweighed by profits from the currency forward and stock futures if speculators engaged in this double or even triple play.[5]

Second, 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

[5] See Cheng and Lui (1998) and Chan and Kwan (1998) for more detailed discussions.

question the wisdom of keeping the currency board, thus creating further pressure on the currency.

Third, the high interest rate apparently had not led to the interest arbitrage expected by the HKMA. The automatic adjustment mechanism would work well only if people had enough confidence in the Hong Kong dollar. Although Hong Kong's interest rate had been persistently higher than that of the US dollar after the onset of the financial crisis, arbitrage had not occurred. Figure 2 highlights such prolonged interest differentials between 1-month HIBOR, the Hong Kong Inter-bank Offered Rate, and LIBOR, the London Inter-bank Offered Rate for US dollar, during the crisis period. A plausible explanation is that the interest rate differential represented a risk premium for holding Hong Kong dollars. If confidence deteriorated, the risk premium, and consequently, the interest differential, would simply go up without initiating a process of arbitrage. To restore the proper functioning of the automatic adjustment mechanism, the perceived risk of the peg must be lowered.

(Insert Figure 2 here: 1-month HIBOR and LIBOR.)

The devaluation risk of the Hong Kong dollar during the Asian financial crisis as perceived by the foreign exchange market and measured by the currency's forward premium indicates a break from the past. More precisely, the forward premium was substantially higher than that in the previous period. As reported in Cheng, Kwan, and Lui (1999), as the Hong Kong dollar came under a major speculative attack against the background of the New Taiwan dollar's float, the annualized forward premium shot up to 15% on October 23, 1997 (the "Black Thursday). The forward 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 forward premium was 6-7.4% during June 11-19 and 10% between August 26 and September 2.

Note that the series of speculative attacks against the Hong Kong dollar took place when Hong Kong's fundamental variables were neither very bad nor deteriorating. First, its foreign reserves continued to rise up to October 1997, when a major currency attack

occurred. 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 (at US$88.6 billion). Second, the unemployment rate in Hong Kong before the Hong Kong dollar crisis (at about 2.5%) 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. There was indeed deterioration in Hong Kong's international competitiveness as measured by its real exchange rate and by its trade balance (goods and services but not including investment income). It might potentially be a weak fundamental variable, but the magnitude of the attacks suggests that other factors might be at work.

Believing that confidence was the key to exchange rate stability, two academics, Alex Chan and Naifu Chen, proposed the issuance of Hong Kong dollar put options, a rule-based exchange rate insurance scheme, as an alternative mechanism of defending the Hong Kong dollar as early as November 1997.[6] After a prolonged public debate, the HKMA finally adopted on 5 September 1998 some "technical" measures that were analytically equivalent to the put options. The main features of these measures are as follows.

First, the HKMA provided a clear undertaking to all licensed banks in Hong Kong to convert Hong Kong dollars in their clearing accounts into US dollars at the fixed exchange rate of HK$ 7.75 per US$ 1.

Second, a Discount Window was established to replace the LAF. Banks can use the Exchange Fund Bills and Notes, which are similar to Treasury Bills of the U.S., as collateral to borrow overnight Hong Kong dollars from the HKMA. The interest rate of the Discount Window, called the Base Rate, is determined by a formula that reflects influences of the Hong Kong Interbank Offered Rate and the Fed Fund rate.

Third, on 14 September 1998, due to market pressure, the HKMA introduced a time element into the convertibility undertaking. It specified clearly that within the following six months, the convertibility undertaking would be at the rate of 7.75. Later on,

[6] See Chan and Chen (1999), Cheng, Kwan and Lui (1999), and Lui, Cheng and Kwan (1999) for more detailed discussions of the proposal of put options.

the HKMA also announced that this rate would be gradually changed to 7.8 over a period of 500 days.

These elements imply that banks can increase liquidity in their clearing accounts up to an amount equal to the value of the Exchange Fund Bills and Notes that they own. Since the convertibility undertaking is applicable to the clearing balances, it is potentially also applicable to the entire Exchange Fund Bills and Notes. Previously, the monetary base consisted of coins in circulation and the Certificates of Indebtedness (CI), which backed up the bank notes. Now it includes also the aggregate balance and the outstanding Exchange Fund Bills and Notes held by banks. As of the end of 1998, CI and coins amount to around HK$ 92 billion, aggregate balance 2.5 billion, and outstanding Exchange Fund Bills and Notes 81 billion (Hong Kong Monetary Authority (1998a)). Thus, the monetary base has almost been doubled. If all the outstanding Exchange Fund Bills and Notes are used as collateral to borrow liquidity, the new aggregate balance can go up from 2.5 billion to more than 80 billion.

These changes have a number of implications. First, when an attack occurs and capital outflow exceeds the original aggregate balance, banks can restore the Aggregate Balance for clearing purposes by using the Exchange Fund Bills and Notes. Unlike in the past, relatively small capital outflow is less likely to cause big interest rate hikes. Second, the Exchange Fund Bills and Notes can be interpreted as vehicles embodying the Hong Kong dollar put options.[7] Banks can use them as collateral to borrow from the HKMA to augment their balance, which is covered by the convertibility undertaking. Third, the Common Law tradition implies that the convertibility undertaking is legally binding. In case the HKMA abandons the peg, it may be liable to compensate the losses of those who have held the Exchange Fund Bills and Notes, which are assets denominated in Hong Kong dollar. In other words, the HKMA has put money where the mouth is. It has signaled to the market that it has the incentive to follow the fixed rules of the currency board.

[7] Professor Merton Miller, who testified at Hong Kong's Legislative Council in November 1998, also shared this view. See Miller (1998).

Thus, after its re-adoption in 1983, the currency board has experienced three different regimes: from a rule-bound regime to a discretion regime, and then back to a rule-bound regime again. These changes in regimes can be regarded as natural experiments that provide us with an opportunity to test the relative merit of rules versus discretion. The following section implements the empirical tests and interprets the results.

3. Is Hong Kong's currency board a credible target zone?

Our strategy is to infer from financial market data the perceived credibility of the currency board arrangement across the three regimes. In this paper we mainly rely on the forward premium (the annualized percentage deviation of the forward exchange rate from the spot exchange rate) for such a purpose, and the interested reader is referred to Lui, Cheng and Kwan (1999) for the analysis using HIBOR – LIBOR interest differentials. More precisely, we 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, *ex ante* 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, or the movement of the exchange rate within the target zone. Let $\Delta c_{t+\tau} = c_{t+\tau} - c_t$ and the average rate of realignment from time t to $t + \tau$ be $\Delta c_{t+\tau} / \tau dt$, and similarly for s_t and x_t. It follows from the identity that

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

The left-hand-side in (1) is the expected rate of change of the central parity, or the implicit risk of devaluation (revaluation if negative) as perceived by the foreign exchange market, a measure of the credibility of the target zone. It can be recovered from observed data by estimating the two expected rates on the right-hand-side in (1). First, the expected rate of

total depreciation, $E_t\Delta s_{t+\tau}/\tau dt$, is identified 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 identified in Section 2 for the 1-month and 3-month horizons. The Chow test indicates 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 1a and 1b lead to the following conclusions.

(Insert Tables 1a and 1b 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.

(Insert Figures 3a – 3d here: Devaluation risk).

Figure 3a 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 3b, 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 3b and 3c. The rapid recovery of credibility after a return to a rule-based currency board in regime 3 was equally dramatic (figure 3d): the devaluation risk dropped by half 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 3d 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, an argument made by some academics (see Cheng and Lui (1998)).

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 4a 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 4b 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 4a and 4b 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 5a and 5b report scatter plots of 1-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 5a 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 5b 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 3b) 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 5a and 5b here: forward premium vs. spot exchange rate)

4. Rules versus Discretion: Institutions and Incentives for Intervention

One may question the above interpretation of results, namely that the lower credibility of the currency board during regime 2 was a result of the HKMA's exercise of discretion. An alternative hypothesis is that regime 2 happened to have included a major crisis. In other words, if a major crisis were to occur during regime 1, then the system would have suffered a similar credibility problem.

There are three answers to the above criticism. First, the demarcation of regimes adopted in the above sections was not based on the appearance of crisis. Rather, it was based on clear changes in institutional arrangements, including the creation of the HKMA, the New Accounting Arrangements, the issue of Exchange Fund Bills, the adoption of the second line defense, and finally the de-emphasis of discretion and the reversion to rules. Second, during regime 1 there was also a major crisis in confidence, namely, the Tiananmen Square incident on June 4, 1989. The annualized forward premium during this crisis was below 3% and lasted for a brief period. In contrast, the forward premium during regime 2 was much larger and remained for a much longer period. Third, a return to a rule-based system in September 1998 was quickly followed by a substantial reduction in the forward premium, even though the global financial markets continued to be uncertain.

But is there any theoretical justification for a more credible system during regime 1? In the currency board literature, there is an emphasis on separating the board from the government. A properly run currency board provides a mechanism that denies the government an option of using the printing press to solve its fiscal problems. The experience of Hong Kong's currency board during regime 1 and regime 2 suggests that the exact institutional arrangements for implementing the currency board also matters. Specifically, their behavior differed under different institutional arrangements.

Before the HKMA took over the inter-bank clearing function, all commercial banks as well as the HKMA had their transactions cleared at the Hong Kong and Shanghai Banking Corporation (HSBC), a private commercial bank. In those days, when capital

flowed out of Hong Kong and inter-bank liquidity tightened when the Exchange Fund purchased the corresponding Hong Kong dollars, the HSBC would extend credit to facilitate settlements. That practice not only was consistent with its profit incentive, but also avoided large fluctuations in the interest rate.

The newly created HKMA was not happy with this situation, because it felt that a capital outflow should trigger an increase in the interest rate in order to induce capital inflow. Thus, it introduced the New Accounting Arrangement to exert more effective control over inter-bank liquidity and hence inter-bank interest rates.[8] Under the RTGS system, the HKMA could engineer interest rate changes when there are capital flows by changing the size of the aggregate balance. In contrast, a private clearing house like the HSBC would only facilitate inter-bank clearing. Unlike a real central bank, it will not use the clearing function to implement certain monetary operations that central banks regard as essential in managing the monetary system. As we explained in section 2, the so-called currency board rule as applied through the aggregate balance of the RTGS system had the unfortunate effect of generating predictable short-term interest rate movements and thus inadvertently assisting the currency speculators.

But why would the HKMA manage the aggregate balance the way it did? There are two possible explanations. First, it did not understand fully the implications of its operation. Its complete reversal in September 1998 of its earlier position seems to support this explanation.[9] Second, central banks find it inherently difficult to resist the temptation of preserving and exercising discretion. That is to say, there may be an inherent incentive problem in preserving discretion, the exercise of which may erode credibility. Such an explanation would be more satisfying from an academic point of view, because it represents an equilibrium outcome rather than outcome based on mistakes and misunderstanding. However, the development of a theoretical model that generates such an outcome will be left to future research.

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[8] See Yam (1991) for a detailed description of the mechanics and the rationale behind the arrangement.

[9] In the *Report on Financial Market Review*, released in April 1998, the HKMA made a rebuttal of the critics of its interest rate hike policy and criticized all alternative policies proposed by the academics.

5. Concluding Remarks

Hong Kong's long history with the currency board has provided us with ample opportunities to understand better the macroeconomic implications of this form of monetary institution. Its experiences in recent years are particularly useful. During the early years after establishing the peg with the US dollar, Hong Kong's currency board was essentially a passive rule-based system. Our empirical results derived using standard methods in the target zone literature show that the automatic adjustment mechanism worked well and the peg was very credible in this period.

The ability to intervene in the exchange market appeared to be too much of a temptation for the government. After having acquired a set of monetary policy tools, the HKMA established a new "first-line defense" of the Hong Kong dollar by intervening actively in the spot foreign exchange market at the exchange rate of 7.75. Contrary to its own belief, and as the evidence in this paper demonstrates, the expansion of intervention tools and increase in discretionary intervention in the money and foreign exchange markets had made the currency board less credible. The erosion in confidence, as reflected by changes in the forward premium despite an ultra-stable spot exchange rate, culminated in even greater intervention during the financial turmoil of 1997 and 1998, including the direct stock market intervention in August 1998.

During the last two weeks in August 1998, the government engaged in an unprecedented massive shopping spree in the stock market intended to push up the stock index, so as to punish what it called market manipulators. In two weeks the government spent up to US$8.8 billion of Hong Kong's foreign reserves, representing about 9% of the total, to fund its HK$118 billion stock purchases. The government has even become the single largest shareholder of HSBC Holdings PLC, one of the world's biggest banks, after acquiring an 8.9% stake over these two weeks. The stock market intervention had triggered a wave of concern over the government's decision to deviate from its renowned free-market policies. Immediately after the stock purchases was over, the Standard &

Poor's Ratings Group downgraded Hong Kong's credit rating, citing the government's decision to wade into the stock market.

Intense market pressure and public criticisms eventually led the HKMA to move back to a rule-based regime. The announcement of some new measures, which in substance were equivalent to issuing put options for the Hong Kong dollar, had calmed the market. The empirical analyses show that there had been a dramatic restoration of confidence. The peg once again was a credible system.

This paper suggests that currency board in actual practice is not necessarily an unchanging institution. Its credibility, however, depends critically on whether the government has the reputation for strictly following fixed rules, rather than relying on discretion. In this sense, this paper may be regarded as an empirical contribution to the debate on rules versus discretion. In the future, we intend to develop a theoretical model to examine the incentive problems of a monetary authority that operates a currency board system.

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Table 1a: 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 1b: 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 1a and 1b:

1. T-values are in parentheses.
2. Dependent variable = $(x_{t+\tau} - x_t)/\tau dt$, dt = 1/261, τ = 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, …, T- τ, 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.

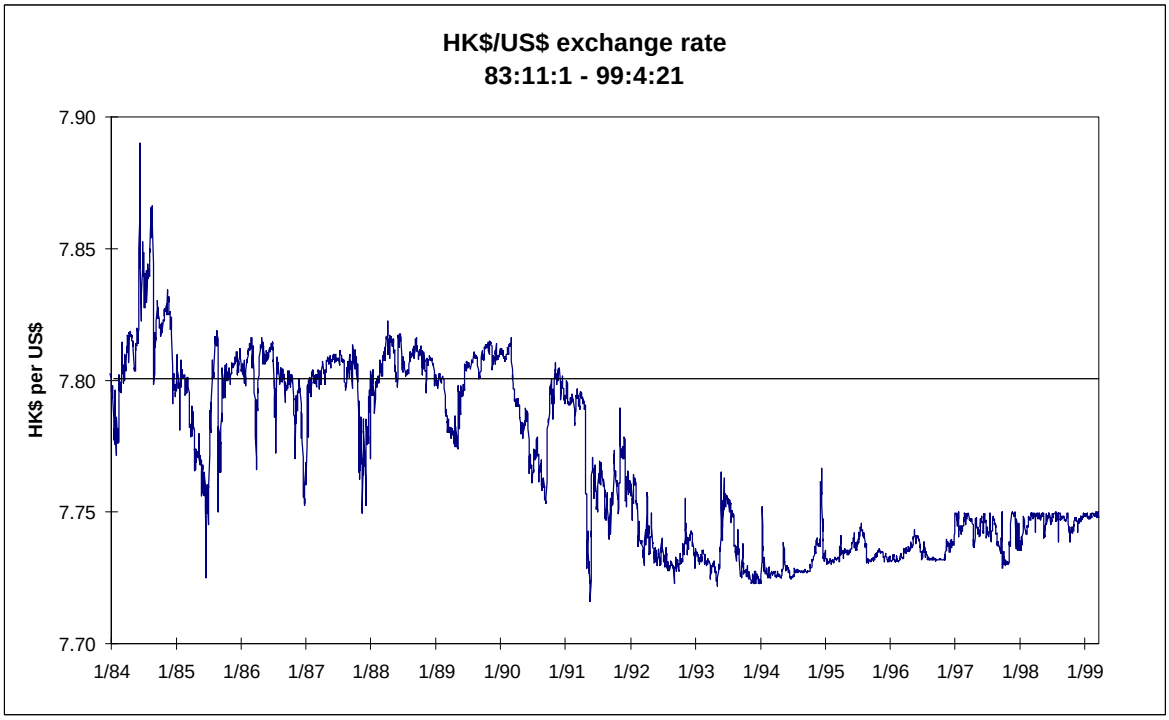

Figure 1: Spot exchange rate

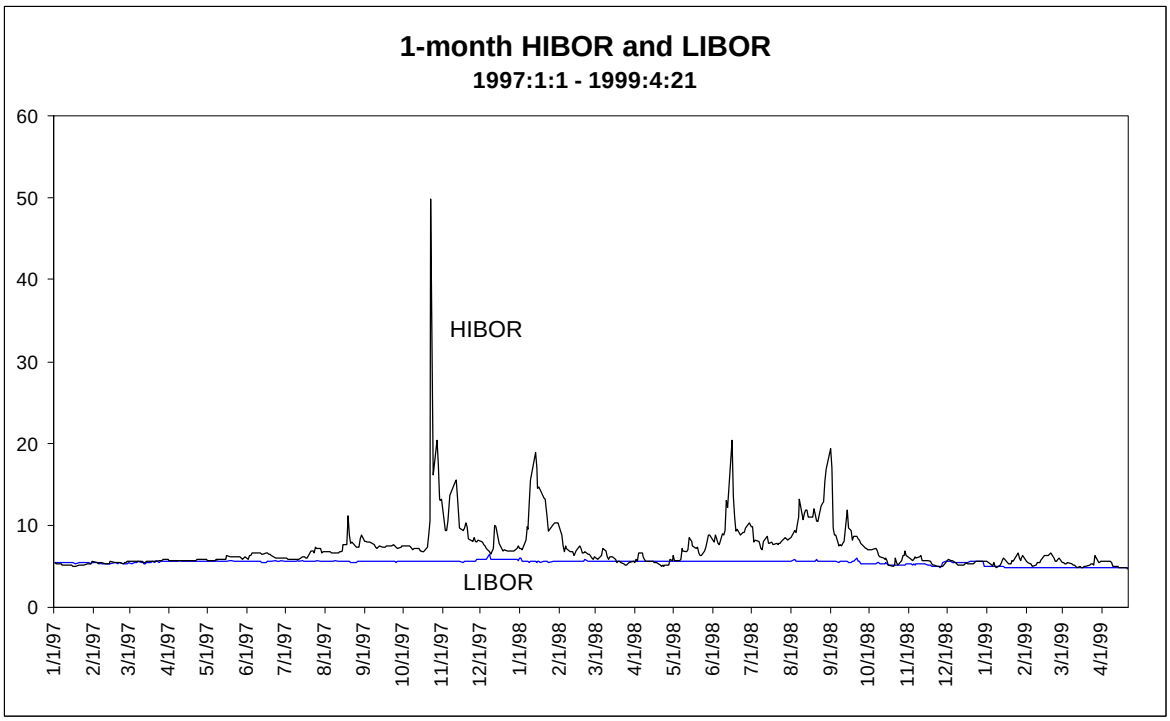

Figure 2: HIBOR and LIBOR

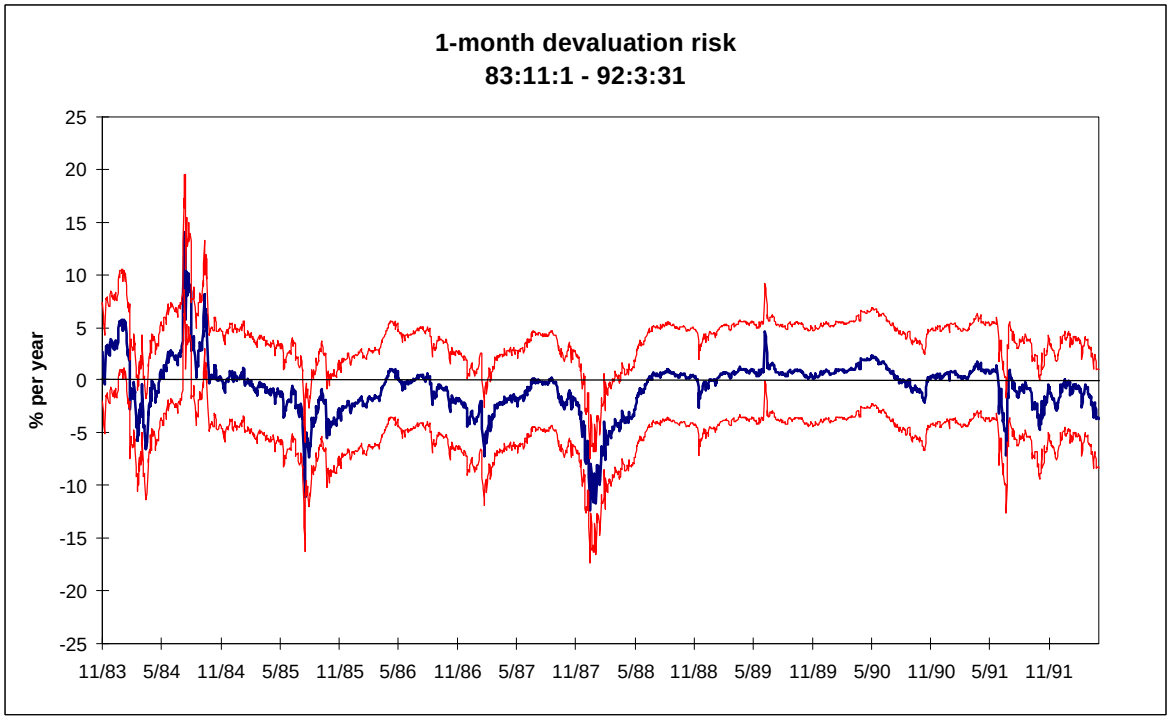

Figure 3a: 1-month Devaluation risk and 2-standard deviation confidence bands

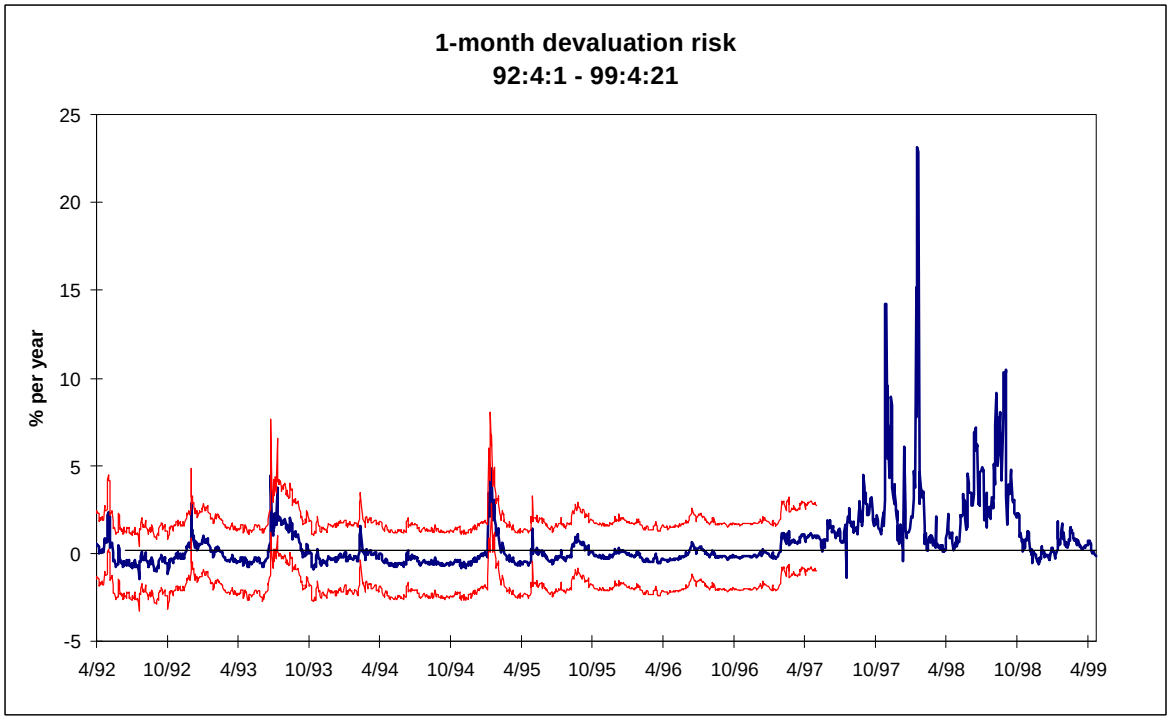

Figure 3b: 1-month devaluation risk and 2-standard deviation confidence bands

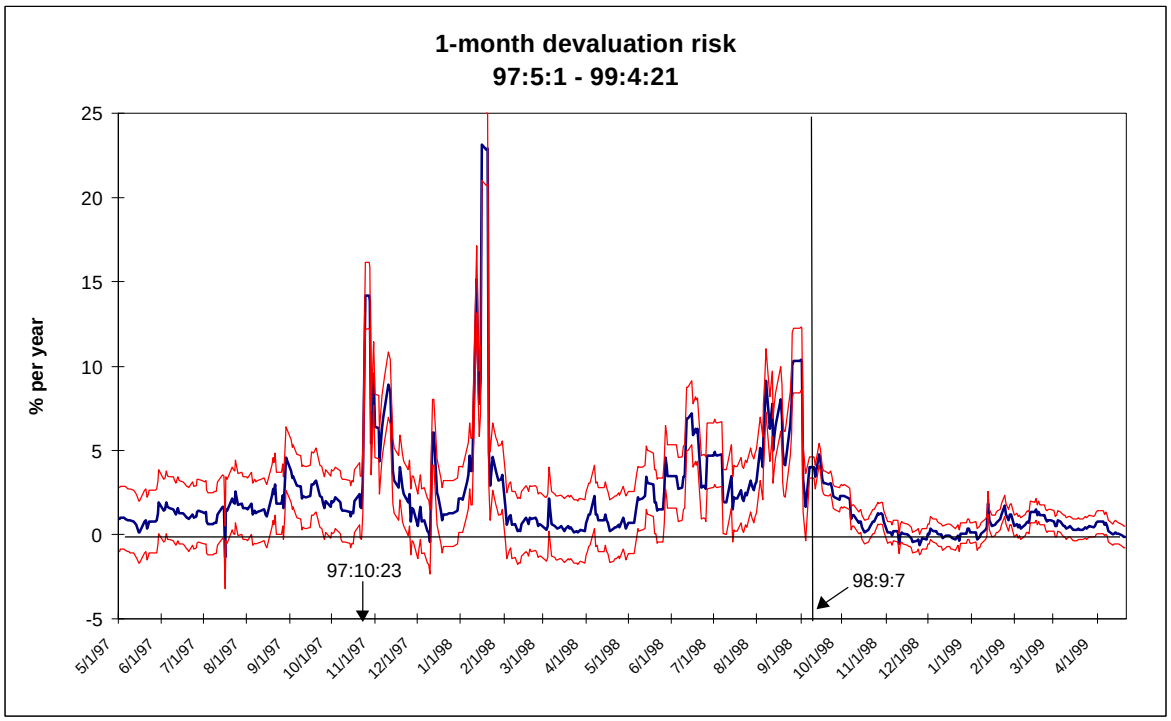

Figure 3c: 1-month devaluation risk and 2-standard deviation confidence bands

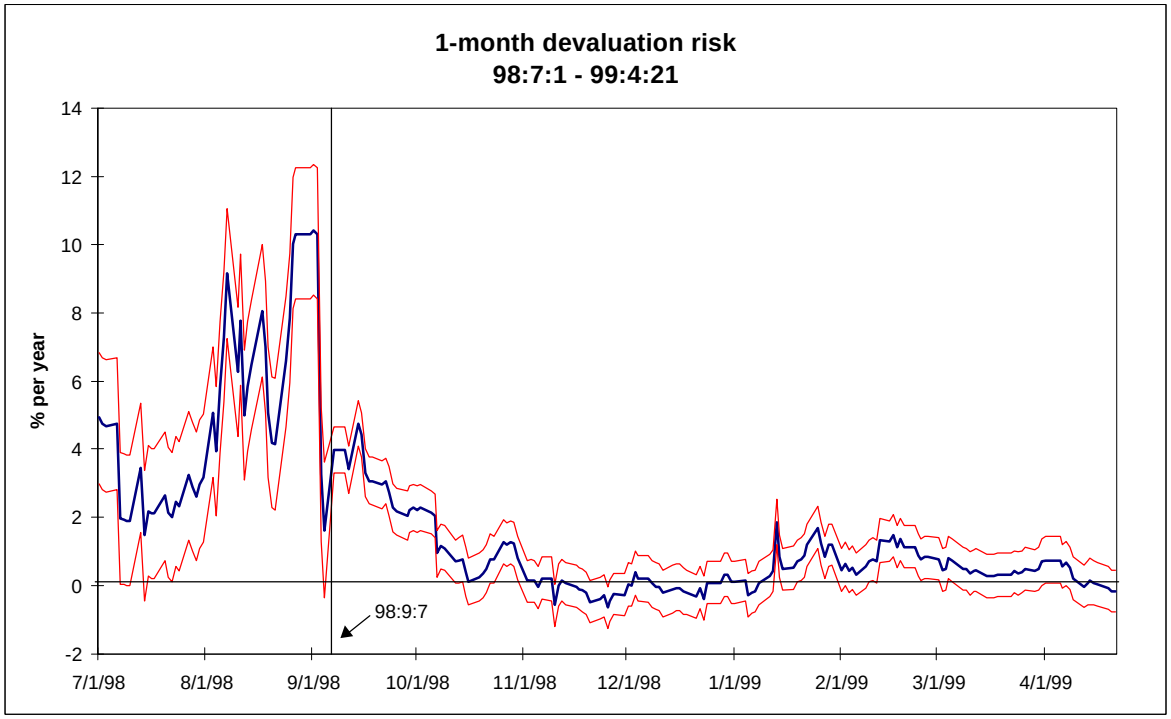

Figure 3d: 1-month devaluation risk and 2-standard deviation confidence bands

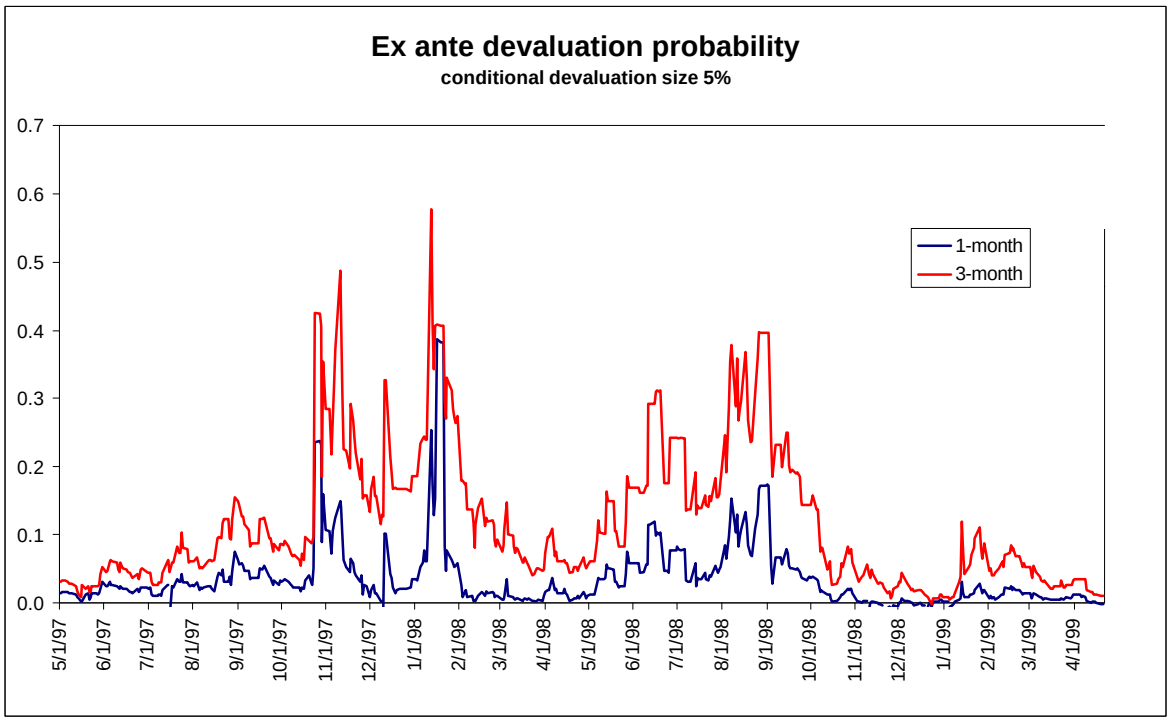

Figure 4a: Devaluation probability

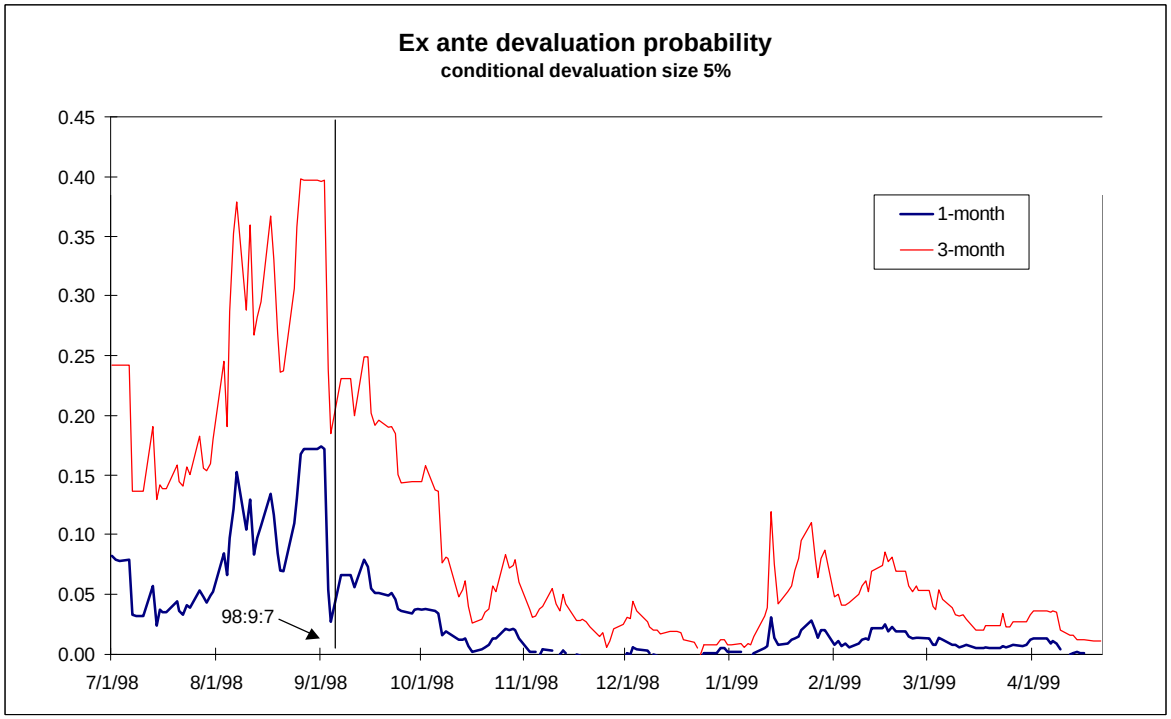

Figure 4b: Devaluation probability

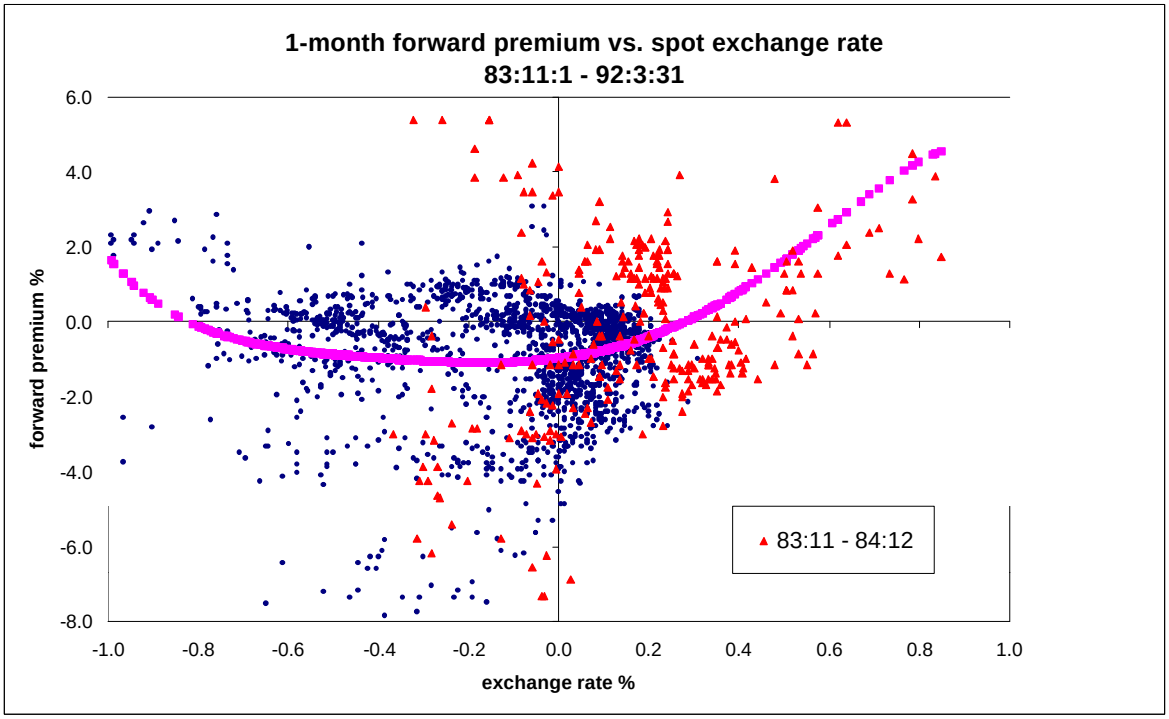

Figure 5a: Forward premium versus spot exchange rate (as percentage deviation from parity)

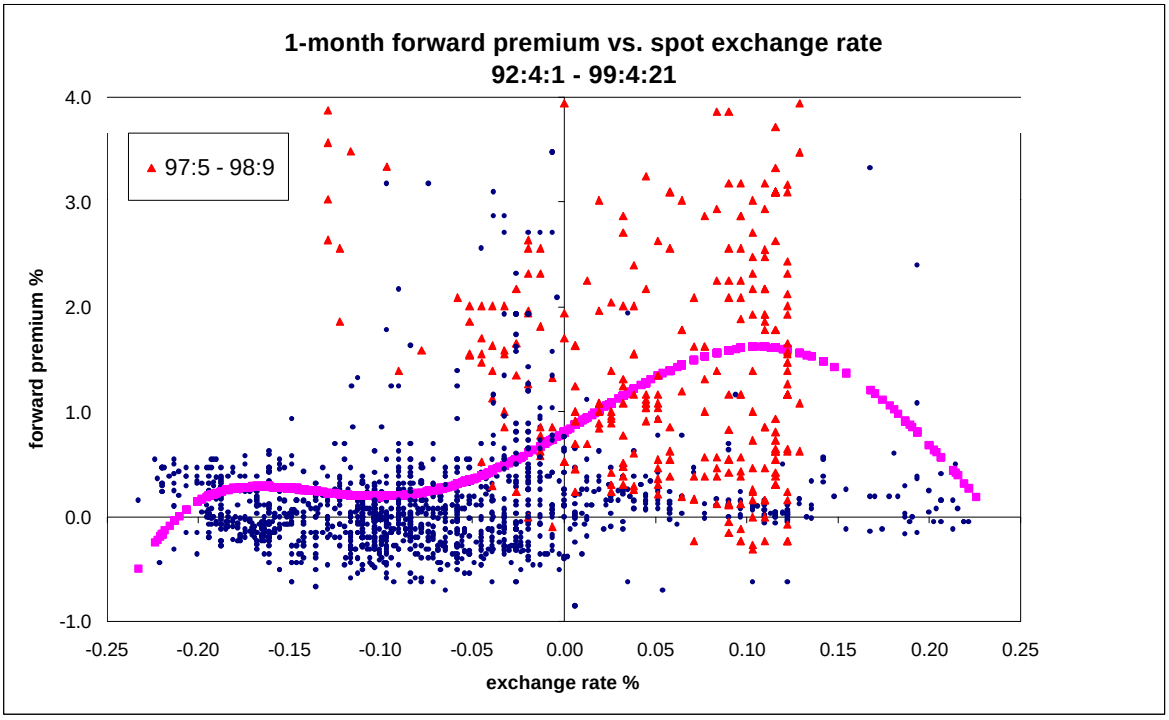

Figure 5b: Forward premium versus spot exchange rate (as percentage deviation from parity)