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Credibility of Hong Kong's Currency Board
The Role of Institutional Arrangements

Yum K. Kwan, Francis T. Lui, and Leonard K. Cheng

7.1 Introduction

Since its introduction in Mauritius in 1849, the 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 mainly adopted in relatively small and unimportant economies. In recent years, the situation has changed. Argentina's readoption of the currency board in 1991 and its subsequent impressive economic growth record has contributed to its credibility as a useful monetary system. Its subsequent adoption in Estonia, Lithuania, and Bulgaria further indicates 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

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

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 abandonment and readoption 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 adopting a 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. The 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 new tools of intervention. However, the trend of greater reliance on discretion was interrupted toward the end of the Asian financial turmoil in 1998, when the HKMA 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 this paper is to test whether the currency board was more credible under the rule-based regimes or under the discretion regime.

The next section discusses the historical background of Hong Kong's currency board, emphasizing 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 7.3 develops and implements empirical tests on the credibility of the currency board under different regimes and interprets our findings. Section 7.4 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.

7.2 An Event Analysis

In this section we briefly outline the history of Hong Kong's currency board. As we shall see, it has not been a static institution. In fact, from October 1983 to the present, the currency board has gone through three major phases: (a) a rule-bound regime, (b) a discretion regime, and (c) a deemphasis of discretion and a return to a rule-based regime with a confidence booster. The primary difference between *rule* and *discretion* is that the former entails commitments about future policy and thus predictability

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

of policy measures, whereas the latter exhibits a lack of commitment and a lower degree of predictability. We shall use this defining characteristic to identify the periods of the three regimes. Our empirical analysis in the next section will demonstrate that the currency board's credibility varied significantly across these 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 Hong Kong 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 repegged to the U.S. dollar. After the collapse of the Bretton Woods system, the government decided to let the currency float on 25 November 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 reestablished the currency board system, but this time the Hong Kong dollar was pegged to the U.S. dollar at the fixed rate of 7.8, and the peg continues to this day.[3]

In other words, the government promised to buy bank notes at the rate of 7.8 per U.S. dollar. However, despite this promise, currency arbitrage through the purchase and sale of bank notes has played little role in locking the spot rate in the market at or near parity. Instead, proximity of the actual spot rate to the parity depends mostly on the HKMA's active intervention in the spot market and capital flows engendered by the interest rate arbitrage.

During the initial period after the peg's reestablishment, the government by and large was following the fixed rules of the currency board passively, maintaining the stability of the spot rate in the foreign exchange market. In 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 U.S. 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 using 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.

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

The gradual "dilution" of the rules, 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 of the spot rate from 7.8 to 7.75. Even though the official parity is 7.8, beginning in 1992 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 7.1 shows that beginning 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 rose above 7.75, the market could fear that the HKMA would choose not to defend the peg. To restore confidence, the HKMA was 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 the 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. Because 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.

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"). As noted earlier, the dilution of rules actually began in 1988. However, the availability of new intervention tools does not necessarily mean that the HKMA had abandoned the rule-based regime. Moreover, it took time for the other policy instruments such as the exchange fund bills and the LAF to come into being and for the market to be convinced that the HKMA was indeed moving towards the discretion regime. We have chosen 1992,

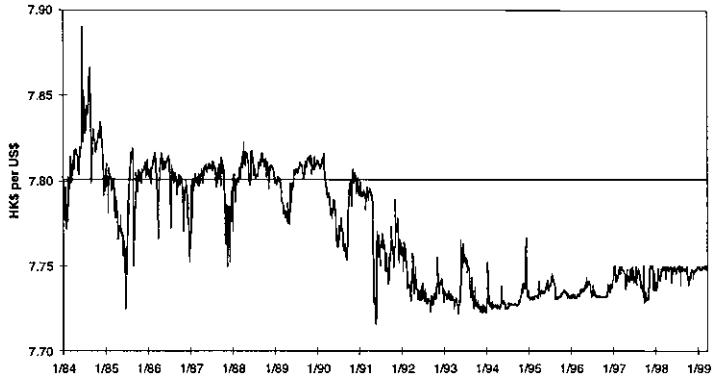

Fig. 7.1 Spot exchange rate, 1 November 1983 to 21 April 1999.

rather than 1988, as the demarcation line, because to us, the strategy of introducing a first-line defense was a clear indication that the HKMA had deviated from an old rule. In implementing the empirical tests, we have also experimented with 1988 as the dividing line between regimes 1 and 2. See section 7.3 for more details.

One may now raise a legitimate question: Is the adoption of a first-line defense a bad rule, instead of the exercise of discretion? We believe it is discretion because despite its actual behavior in the foreign exchange market, the HKMA never made any explicit commitment to the exchange rate of 7.75 for any specified length of time. In addition, its sudden decision effectively to close down the LAF on 23 October 1997 was always an element of its discretion, even though the HKMA never exercised it until that particular date when the Hong Kong dollar came under a major attack. A more detailed description of what happened on that day will be presented later. Again, there was no commitment about the supply of short-term liquidity to facilitate interbank clearing until the beginning of regime 3 (defined in the following paragraph). Nevertheless, one can still raise the question: Was the HKMA's management of the interbank clearing balance during regime 2 the adoption of a bad rule, perhaps due to a lack of understanding of the operation of the interbank clearing system? As will be seen in section 7.5, we leave the question open.

Regime 2 lasted until 7 September 1998, from which time there was a deemphasis of discretion and a return to a rule-based regime, but with new rules ("regime 3"). These were adopted in the midst of the Asian financial turmoil. Until early September 1998, the HKMA relied on interest rate arbitrage (the so-called automatic adjustment mechanism or autopiloting) 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 Hong Kong dollar's defense against speculation. Although the interest rate arbitrage argument makes intuitive sense, its ineffectiveness as a deliberate policy tool against currency speculation cannot be well understood without knowing the implications of the real-time gross settlement (RTGS) system in conjunction with the HKMA's actions on 23 October 1997, which was known as Black Thursday in Hong Kong.

On 9 December 1996 the HKMA introduced a new interbank payment system, the RTGS.[4] The aggregate balance of the banking system, which can be regarded as the lubricant for interbank settlements, was subject to what the HKMA regarded as an inescapable monetary rule of a currency board. Because the RTGS was very efficient, the aggregate balance typi-

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

cally stayed at a low level of around roughly HK$2 billion. As the HKMA has recognized, the small size of the balance was conducive to high interest rate volatility. In other words, even a minor capital outflow could cause the interest rate to shoot up significantly under the said monetary rule. To illustrate the mechanics of how the interest rate would rise following a very minor capital outflow, 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 Hong Kong dollars for, say, U.S. dollars. If the U.S. dollars cannot be purchased within the banking system, then the banks must buy from the HKMA, and they can do so *only* by using the deposits in their clearing accounts. If a bank does not have enough money in its clearing balance for purchasing the U.S. dollars ordered by its clients, it will have to borrow from the clearing balances of other banks. However, because the total outflow of capital exceeds the aggregate balance, the banks simply cannot settle their committed transactions, and thus the interest rate may rise 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 interbank settlement system. After buying Hong Kong dollars in the aggregate balance, the HKMA could delay the injection of Hong Kong dollar liquidity back into the system. In such a situation, the aggregate balance would shrink in size until the interest rate was squeezed up to such an extent that the banks would suffer a smaller loss by using their foreign currency to buy back the Hong Kong dollars from the HKMA to square their accounts. However, since these Hong Kong dollars would not be delivered until one or two days later, the banks still had 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. On the morning of 23 October 1997 the HKMA sent a surprising memorandum to all the licensed banks in Hong Kong, warning them that they might have to pay penalty interest rates 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 1,000 percent. The interbank interest rate shot up. At its peak, the rate was close to 300 percent.

Thus, the monetary system in Hong Kong was such that the interest rate was very sensitive to capital flows. In addition, the HKMA might choose

to magnify interest rate volatility through such discretionary measures as changing the time of liquidity injection or imposing a penalty interest rate. Until early September 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 criticism 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, a 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 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 could 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 U.S. dollar after the onset of the financial crisis, arbitrage had not occurred. Figure 7.2 highlights such prolonged interest differentials between the one-month Hong Kong Interbank Offered Rate (HIBOR), and the London Interbank Offered Rate (LIBOR) for U.S. dollar, during the crisis period. A plausible explanation is that the interest rate differential represented a risk premium for holding the Hong Kong dollar. If confidence deteriorated, the risk premium, and consequently the interest differential, would simply go up without initiating a process of arbitrage. To restore proper functioning of the automatic adjustment mechanism, the perceived risk of the peg must be lowered.

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 it was in the

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

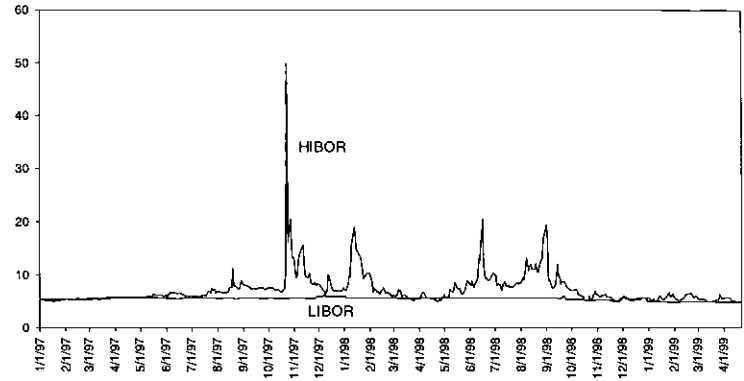

Fig. 7.2 One-month HIBOR and LIBOR, 1 January 1997 to 21 April 1999.

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 percent on 23 October 1997 (Black Thursday). The forward premium reached 24 percent in the period 12–20 January 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 percent during 11–19 June and 10 percent between 26 August and 2 September.

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 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 percent) was low even by historical standards. 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 were at work.

The relationship between the exchange rate of the Hong Kong dollar and the interest rate differential (HIBOR − LIBOR) can be captured by figure 7.3. Line AB denotes the situation when the currency board is completely credible. The exchange rate is exactly 7.8 when the difference between HIBOR and LIBOR is zero. An increase in the difference will make the Hong Kong dollar stronger. In other words, autopiloting works. If con-

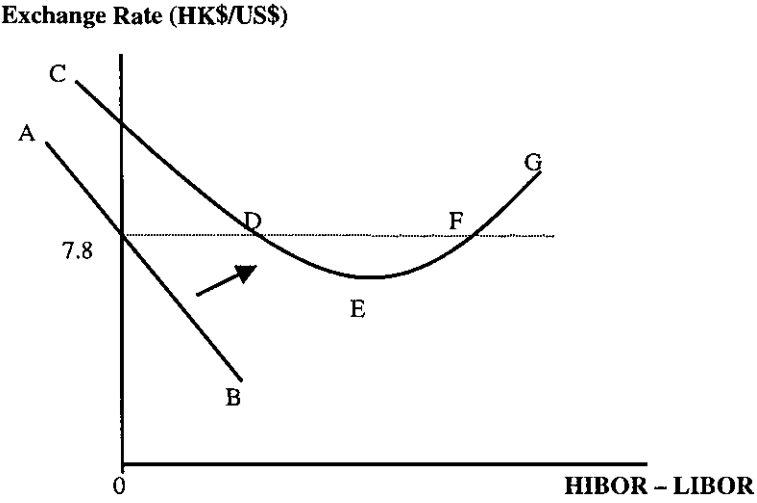

Fig. 7.3 Relationship between exchange rate and interest rate differential

fidence in the Hong Kong dollar deteriorates, the curve moves to CEG. A higher interest rate differential is needed to compensate the risk of holding the Hong Kong dollar or to maintain exchange rate stability (point D). That the HKMA had deviated from the fixed rules of the currency board made its commitment to the peg much less credible. The problem could be worsened if the interest rate were significantly pushed up due to cornering of the market or discretionary measures of the HKMA. The economic and political costs of a very high interest rate could lead more people to believe that the peg would not be sustainable, which would weaken the Hong Kong dollar. This is represented by the positively sloping curve EFG in figure 7.3. Interest rate arbitrage does not work in this case. An increase in the interest rate under such conditions is not conducive to strengthening the Hong Kong dollar.

Believing that confidence was the key to exchange rate and interest rate stability, 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 implemented (on 7 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

6. See Chan and Chen (1999); Cheng, Kwan, and Lui (1999); and Lui, Cheng, and Kwan (2000) for more detailed discussions of the proposal of put options.

Hong Kong to convert Hong Kong dollars in their clearing accounts into U.S. 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 now use the exchange fund bills and notes, which are similar to U.S. Treasury bills, 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 HIBOR and the federal 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, 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. Because the convertibility undertaking is applicable to the clearing balances, it is potentially also applicable to all exchange fund bills and notes. Previously, the monetary base consisted of coins in circulation and 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 amounted to around HK$92 billion, aggregate balance HK$2.5 billion, and outstanding exchange fund bills and notes HK$81 billion (Hong Kong Monetary Authority 1998a). Thus, the monetary base has almost doubled. If all the outstanding exchange fund bills and notes are used as collateral to borrow liquidity, the new aggregate balance can rise from HK$2.5 billion to more than HK$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. The newly established discount window and its associated base rate were an explicit commitment on the part of the HKMA. As a result, short-term liquidity for the purpose of interbank clearing has become predictable. Unlike in the past, relatively small capital outflow is now 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 option.[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 convertibility undertaking is equivalent to a Hong Kong dollar put option because Hong Kong's common law tradition implies that the undertaking is legally binding. If the HKMA

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

abandons the peg, it would be liable to compensate the losses of those who have held the exchange fund bills and notes, which are assets denominated in Hong Kong dollars. In other words, the HKMA has put its money where its mouth is. It has signaled to the market that it has the incentive to follow the fixed rules of the currency board.

Thus, 7 September 1998 can be regarded as the dividing line between regimes 2 and 3. Before this date, the fixed rules of a currency board had been substantially diluted by discretionary measures. The HKMA actively pursued the first line of defense by using its intervention tools without making any commitment to its new target exchange rate. It also artificially amplified interest rate volatility by draining liquidity directly from the RTGS's aggregate balance and imposing penalty interest rates on users of the LAF. After that date, the HKMA established a discount window whose base rate was determined by an explicit formula and both adopted a plan to abandon the first line of defense gradually by moving the central parity of the fixed exchange rate back to the 7.8 over a 500-day period and clarified the nature of its convertibility undertaking. Under these new institutional arrangements, it would be much harder for the HKMA to manipulate the interest rate.

In short, the currency board in Hong Kong, after its readoption in 1983, 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 empirical tests and interprets the results.

7.3 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 rely mainly 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 (2000) 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. Before we proceed, however, we should emphasize that contrary to the belief of some HKMA officials, the apparent stability of the spot exchange rate is by itself *not* proof of the peg's future credibility. The forward premium, however, does capture the market's expectation of the exchange rate's risk of devaluation.

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

$$E_t\left[\frac{\Delta c_{t+\tau}}{\tau dt}\right] \equiv E_t\left[\frac{\Delta s_{t+\tau}}{\tau dt}\right] - E_t\left[\frac{\Delta x_{t+\tau}}{\tau dt}\right]. \tag{1}$$

The left-hand side in equation (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 equation (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 heteroscedasticity autocorrelation consistent matrix of τ lags:

$$\frac{\Delta x_{t+\tau}}{\tau dt} = z_t'\beta + \varepsilon_{t+\tau}. \tag{2}$$

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 twelve-month and one-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, Soderlind, and Svensson 1993; Lindberg and Soderlind 1994; Rose and Svensson 1994; 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 7.2 for the one-month and three-month horizons. The Chow test indicates that there have been significant structural changes across the three regimes, which provides empirical support to our three-regime demarcation scheme. Besides providing an estimate of the expected drift, the projection equations are of interest in their own right. The estimation results reported in tables 7.1 and 7.2 lead to the following conclusions.

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 reversion, a property emphasized in Krugman's (1991) fully credible target zone model, is mixed, however. Nonlinear mean reversion shows up in regimes 1 and 3 in the one-month case, and also in regime 3 in the three-month case, as indicated by the small *p*-values of Wald tests reported in the rows titled "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 a 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.

As discussed in section 7.2, 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 also have performed the same econometric analysis reported in

Table 7.1 **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 premium	−0.8020	−0.8561	0.1606	0.1506	0.0164	0.0094
	(−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 and P_3		[0.0014]		[0.2967]		[0.0070]
Sample size	2174	2174	1656	1656	141	141

Notes: *t*-values are in parentheses. Dependent variable = $(x_{t+\tau} - x_t)/\tau dt$, $dt = 1/261$, $\tau = 22$ and 65 (business) days corresponding to one-month and three-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. Regime 1 = 1983:11:1 to 1992:3:31; Regime 2 = 1992:4:1 to 1998:9:6; and Regime 3 = 1998:9:7 to 1999:4:21, excluding holidays. $P_1(x)$, $P_2(x)$ 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). "Yield curve slope" is the differential between twelve-month and one-month forward premium. "Exclude P_2 and P_3" reports the χ^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 nonlinearity is indicated by a small *p*-value. All equations are estimated by ordinary least squares with Newey-West covariance matrix of τ lags.

Table 7.2 **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 premium	−0.3402	−0.3739	0.0971	0.0938	−0.0258	−0.0326
	(−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 and P_3		[0.1496]		[0.1022]		[0.0001]
Sample size	2131	2131	1613	1613	98	98

Note: See table 7.1.

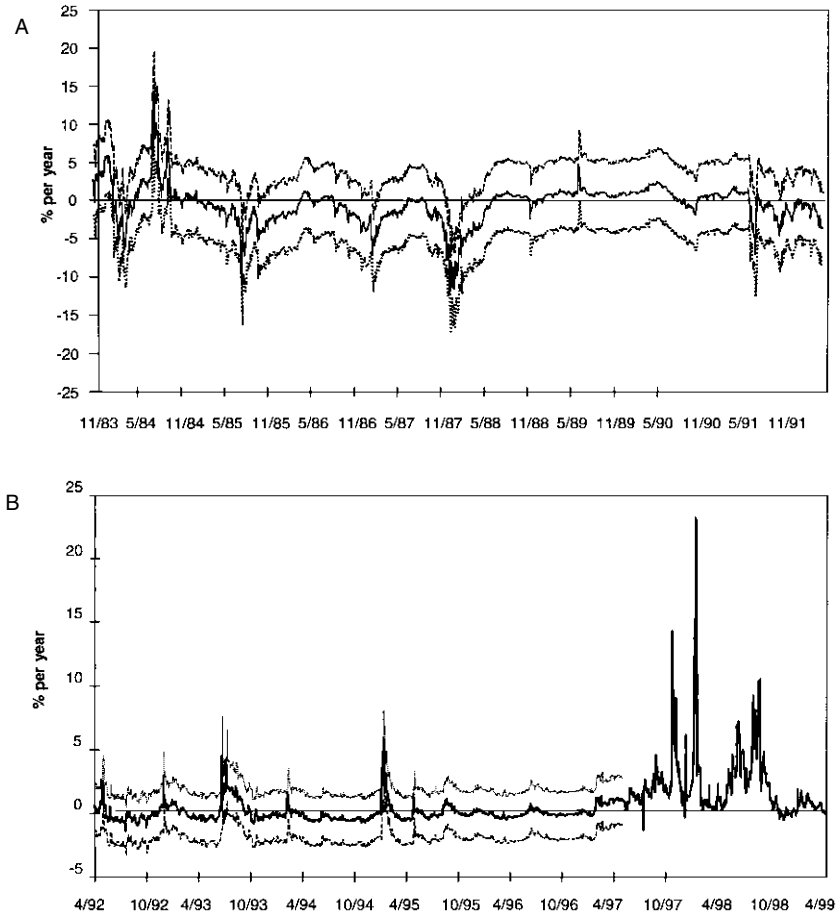

Fig. 7.4 One-month devaluation risk and 2–standard deviation confidence bands: *A*, 1 November 1983 to 31 March 1992; *B*, 1 April 1992 to 21 April 1999; *C*, 1 May 1997 to 21 April 1999; *D*, 1 July 1998 to 21 April 1999.

tables 7.1 and 7.2 on data using 1988 as the dividing line. The general results remain the same, although there is a slight drop in statistical significance.[8]

Panel A of figure 7.4 depicts the estimated one-month devaluation risk together with 2–standard deviation confidence bands for regime 1. The devaluation risk is statistically significant at the 5 percent level if zero lies outside of the bands. We see that most of the time the devaluation risk was not significant, except for a few short intervals during which the deval-

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

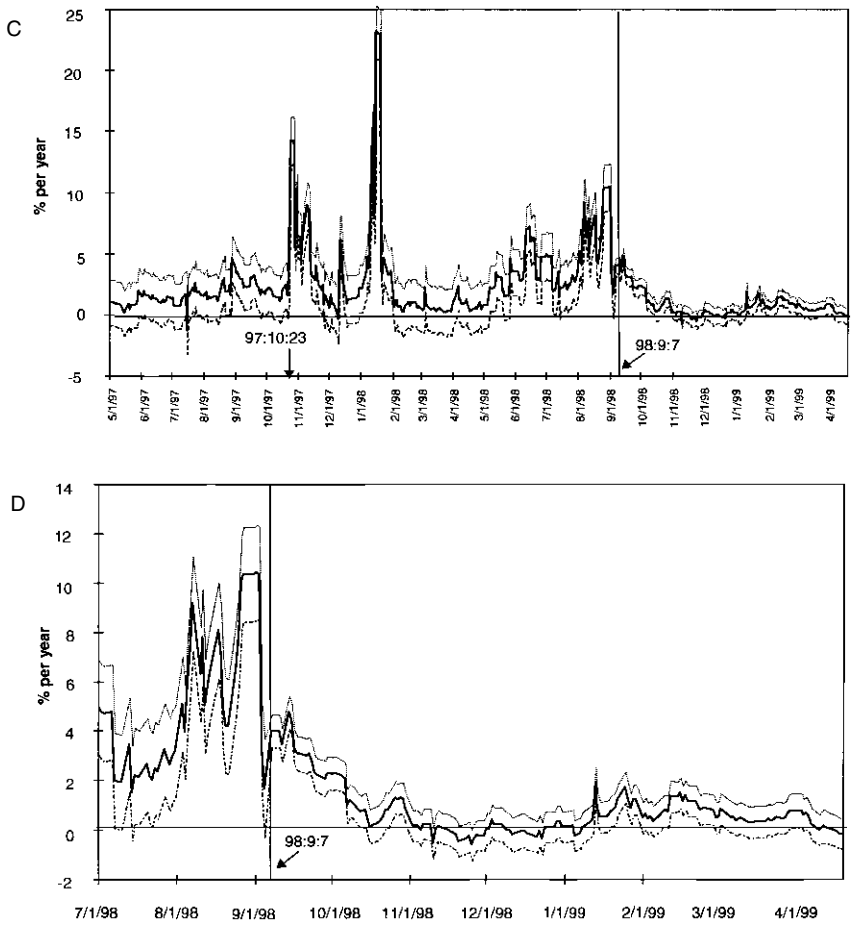

Fig. 7.4 (cont.)

uation risk was significantly different from zero. This shows that the peg was generally credible in the rule-bound regime. In panel B of figure 7.4 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 is shown in panels A and B of figure 7.4. The rapid recovery of credibility after the return to a rule-based currency board in regime 3 was equally dramatic (panel D of figure 7.4): The devaluation risk dropped by half overnight after the announcement on 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 as 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 the 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 panel D of figure 7.4 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 researchers (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

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

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

$$E_t\left[\frac{\Delta c_{t+\tau}}{\tau dt}\right] = v_t^\tau E_t[\Delta c_{t+\tau} | realignment], \tag{4}$$

where $v_t^\tau \equiv p_t^\tau/\tau dt$ is by definition the expected average frequency of realignment during the period from time t to $t + \tau$. To illustrate how the devaluation probability can be calculated, suppose that the three-month devaluation risk is 7 percent and the expected devaluation size is 5 percent. In annual terms, $\tau dt = 1/4$ year. Using equation (4), $v_t^\tau = 7/5 = 1.4$, and $p_t^\tau = 1.4/4 = 0.35$. Panel A of figure 7.5 shows the probabilities that the Hong Kong dollar would be devalued by 5 percent 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 percent within three months was as high as 60 percent. An equivalent interpretation is that the probability of a 15 percent devaluation within three months would be 20 percent. Judged by the extent of devaluation by the New Taiwan dollar and Singapore's dollar around that time, a 10–20 percent 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 depegging of the Hong Kong dollar, panel B of figure 7.5 highlights

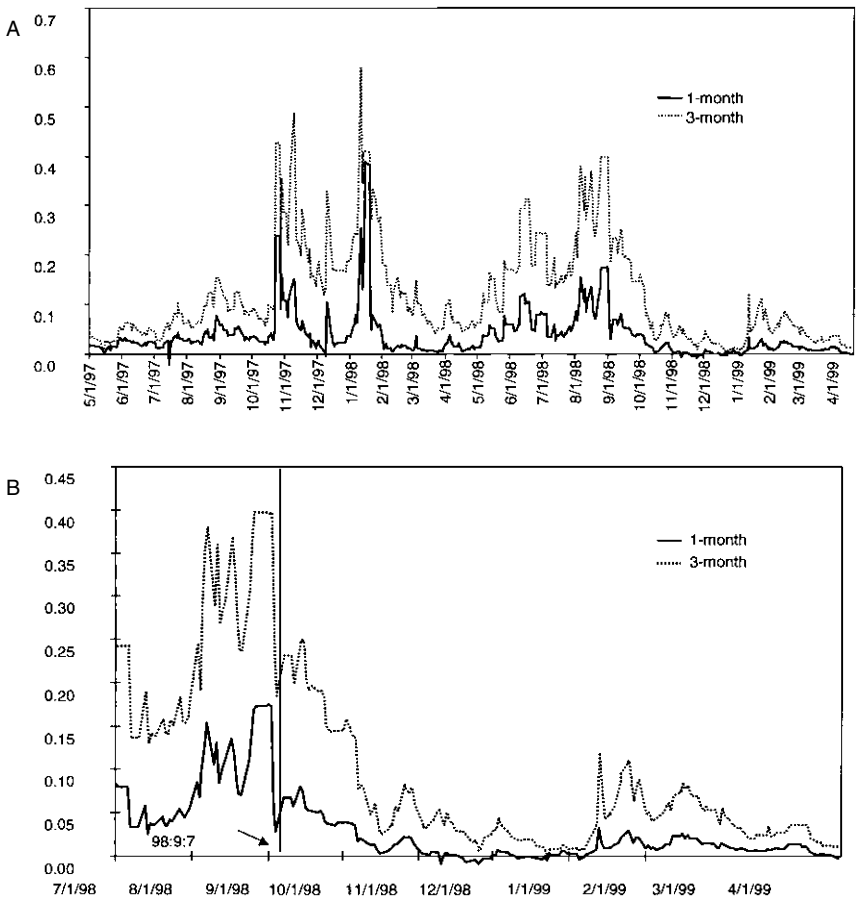

Fig. 7.5 Ex ante devaluation probability (conditional on devaluation size = 5 percent): *A*, 1 May 1997 to 1 April 1999; *B*, 1 July 1998 to 1 April 1999.

the rapid drop in devaluation probability soon after the beginning of regime 3. The following events are particularly revealing: the dramatic fall in probability after the announcement on 5 September of a new regime, the spike before the 14 September clarification of the convertibility undertaking, and the immediate calming in market sentiments right after the clarification.

The relationship between the forward premium and the current position of the exchange rate reveals further information about the credibility of a target zone. As is shown by Bartolini and Bodnar (1992), the relationship can exhibit a variety of shapes depending on the monetary authority's credibility and its 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.

Figure 7.6 reports scatter plots of one-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 Bartolini and Bodnar (1992). The U-shape pattern in panel A of figure 7.6 is due mainly 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 gain credibility, as indicated by the cloud of points in the northwest and southeast quadrants.

The bimodal curve in panel B of figure 7.6 matches exactly the case of asymmetric credibility and discrete intervention analyzed by Bartolini and Bodnar (1992, fig. 10, p. 388). It can be seen that the hump in the northeast quadrant is due mainly 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 postcrisis observations. In other words, the crisis works like a natural experiment that provides the observations crucial 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 7.1 and panel B of 7.4) was not the result of more intervention power as claimed by HKMA; rather, it was because the system had not yet been subject to a shock large enough.

7.4 Rules versus Discretion: Institutions and Incentives for Intervention

One may question the previous 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—namely, the Asian financial 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 first line defense, and the deemphasis 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 4 June 1989. Was the shock to

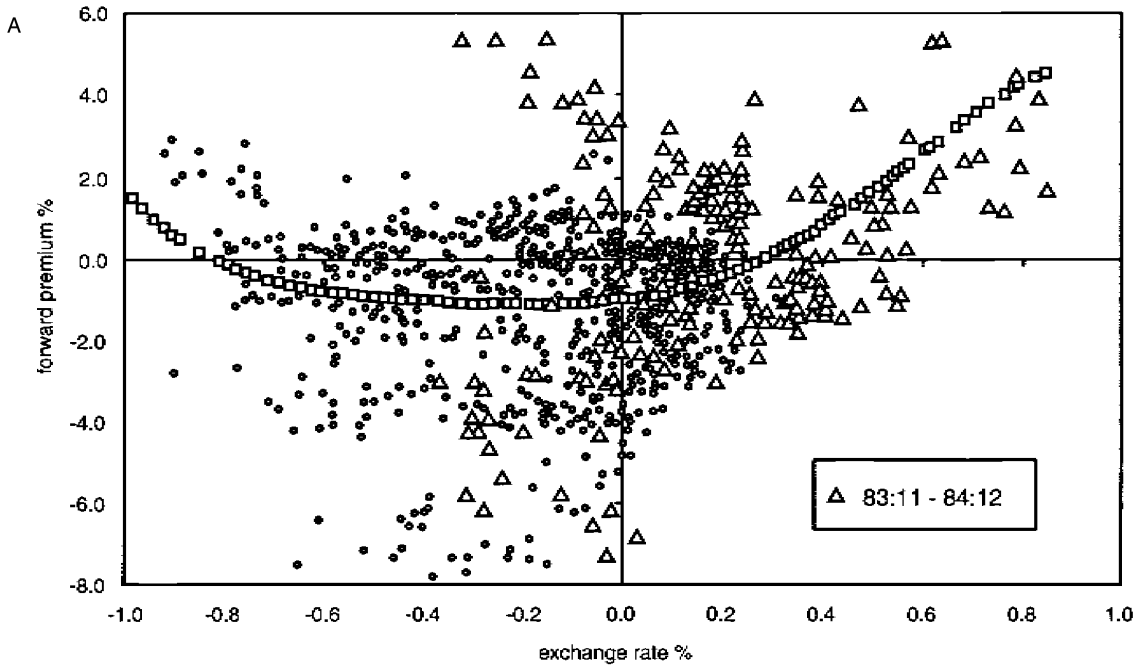

Fig. 7.6 Forward premium versus spot exchange rate (as percentage deviation from parity): *A*, 1 November 1983 to 31 March 1992; *B*, 1 April 1992 to 21 April 1999.

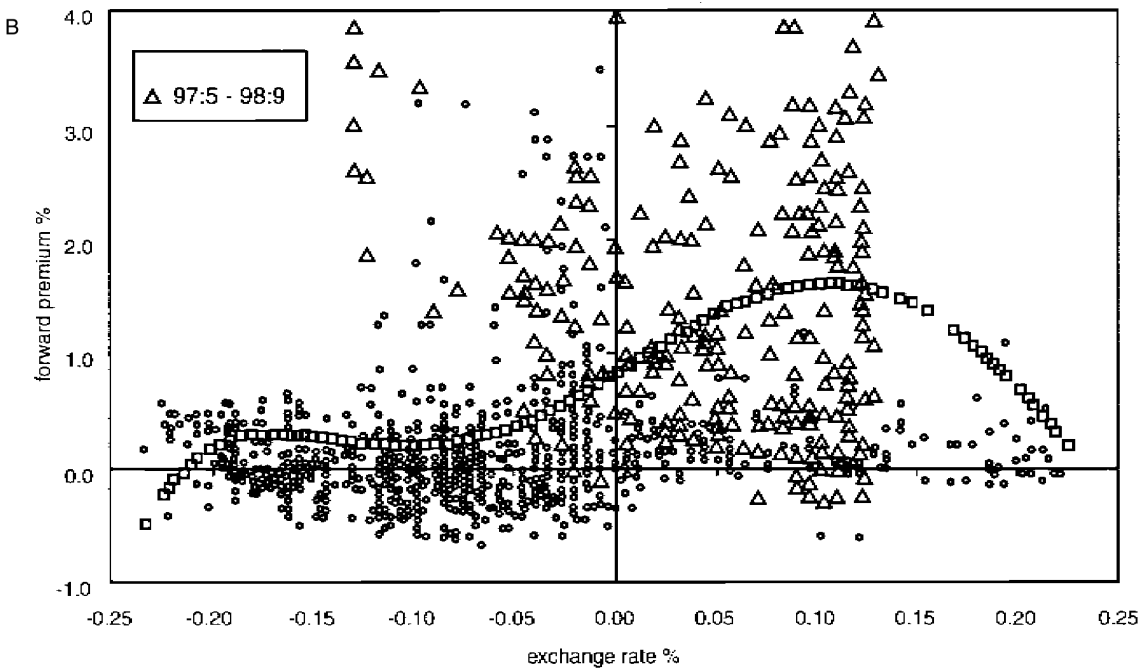
B
97:5 - 98:9
forward premium %
4.0
3.0
2.0
1.0
0.0
-1.0
-0.25
-0.20
-0.15
-0.10
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
exchange rate %

Fig. 7.6 (cont.)

confidence of the Tiananmen incident as bad as the Asian financial crisis? On 5 June 1989 the Hang Seng stock price index fell by 21.75 percent from the previous business day. In comparison, the Hang Seng index fell on 23 October 1997 (Black Thursday) by 10.4 percent from the last business day.[9]

Despite the comparability in the decline of stock and real estates prices, the annualized forward premium during the Tiananmen incident was below 3 percent and lasted only for a brief period. In contrast, the forward premium during the height of the Asian financial crisis was much larger and lasted 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.

Despite the above arguments, we acknowledge that if the Asian financial crisis is regarded as truly unique, then the counterargument that the Hong Kong currency board's behavior during regime 2 was due to the deterioration in Hong Kong's external environment (i.e., the contagion effect) would remain a viable, though nonrefutable, hypothesis.

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 the 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 interbank 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 interbank 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 interbank liquidity and

9. Real estate property prices adjusted more slowly than did stock prices. Unfortunately, we have not found property price indexes that are more frequent than quarterly indexes. The index for domestic premises for the quarter ending September 1989 dropped by 3 percent from the previous quarter. The same index ending December 1997 dropped by 2.5 percent from the previous quarter.

hence interbank interest rates.[10] Under the RTGS system, the HKMA could engineer interest rate changes when there were capital flows by changing the size of the aggregate balance. In contrast, a private clearing house like the HSBC would only facilitate interbank clearing. Unlike a real central bank, it would not use the clearing function to implement certain monetary operations that central banks regard as essential to managing the monetary system. As we explained in section 7.2, 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 of inadvertently assisting the currency speculators.

Why would the HKMA have managed the aggregate balance the way it did? There are two possible explanations. First, it did not fully understand the implications of its operations. Its complete reversal of its earlier position in September 1998 seems to support this explanation.[11] Second, central banks find it inherently difficult to resist the temptation to preserve and exercise 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 represent an equilibrium outcome rather than an outcome based on mistakes and misunderstandings. As such, it might be more appealing from certain academic perspectives. However, whether such a theoretical model can be developed is a topic for future research.

7.5 Concluding Remarks

Hong Kong's long history with a currency board has provided us with ample opportunities to better understand 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 U.S. 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 that the peg was very credible in this period.

Unfortunately, the ability to intervene in the exchange market appeared to be too much of a temptation for the government. After gradually expanding its set of monetary policy tools, the HKMA engaged in more discretionary intervention in the money and foreign exchange markets. Contrary to the HKMA's own belief, and as the evidence in this paper has

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

11. In the *Report on Financial Market Review* (Hong Kong Special Administrative Region Government 1998), released in April 1998, the HKMA made a rebuttal to the critics of its interest rate hike policy and criticized all alternative policies proposed by the academics.

demonstrated, the expansion of intervention tools and actual intervention made the currency board less, rather than more, credible. The erosion in confidence, as reflected by changes in the forward premium despite an ultrastable 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 of August 1998, the government engaged in an unprecedented and massive buying spree in the stock market, intending to push up the stock index 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 percent 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 percent stake over these two weeks. The stock market intervention 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, Standard & Poor's downgraded Hong Kong's credit rating, citing the government's decision to wade into the stock market.

Intense market pressure and public criticism eventually led the HKMA to return 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 immediately calmed the market, and the calm remained even during the subsequent Russian debacle and the Long-Term Capital Management (LTCM) event. 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 a currency board in actual practice is not necessarily a static institution. Its credibility, however, depends critically on whether the government has a reputation for following fixed rules strictly, 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.

Finally, we want to point out that we have not dealt with many of the challenges to Hong Kong's currency board. For example, is the U.S. dollar the optimal currency to which the Hong Kong dollar should link? This calls for a cost and benefit analysis along the lines of optimum currency area theory (Mundell, 1961). In the past, because the United States was a much more important importer of Hong Kong goods than other countries such as Japan, business cycles in Hong Kong tended to be synchronized with those in the United States. This eliminated many difficulties associated with a fixed exchange rate. By standard optimum currency area arguments, the cost of losing the exchange rate as an adjustment mechanism

can be severe when there are asymmetric shocks affecting the members of a monetary union afflicted with wage and price rigidities, which have no choice but to endure the slow and painful process of internal wage-price adjustment. However, as Hong Kong's economy has become more integrated with China, it is not clear that it will continue to share the same shocks as will the United States.[12] This fact alone may already create pressure on the sustainability of the U.S. dollar peg and raise doubt about the credibility of the currency board system itself.

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12. Frankel and Rose (1997) empirically demonstrated the endogeneity of business cycle symmetry (i.e., as an indicator of the nature of underlying shocks) with respect to trade integration. They found that a closer trade linkage between two countries is strongly and consistently associated with more tightly correlated cyclical fluctuations in the two countries.

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Comment

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This paper is an interesting case study on credibility and the currency board in Hong Kong. After providing a compact yet comprehensive historical overview on the Hong Kong currency board, the paper presented a sophisticated empirical study of the Hong Kong dollar devaluation risk

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