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Fixing the Exchange Rate through a Currency Board Arrangement: Efficiency Risk, Systemic Risk and Exit Cost

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Abstract

There are two major ways to fix an exchange rate: (1) exchange controls and government interventions in the market; and (2) arrangements that activate self-interested market forces, including the gold standard and currency board arrangements (CBAs). While the gold standard is now history, currency boards have become fashionable lately. In essence, a CBA issues narrow money, typically cash, with 100% foreign exchange reserves, and can theoretically fix the exchange rate of broad money through two automatic stabilizers: specie-flow and cash arbitrage. They appeal to “selfish” behaviour of market participants, without invoking the need for government interference.

In a modern financial economy with large cross-border flow of funds and a diminishing cash base, both the presumed automatic stabilizers for the classical CBA are thrown into serious doubt. Hong Kong's linked exchange rate system (the link) is used as the key example to illustrate the “efficiency risk” of a CBA failing to firmly anchor the spot exchange rate, in the light of the recent speculative currency attacks in East Asia.

There are alternatives to strengthen a CBA by reducing its efficiency risk, e.g. the convertible reserves mechanism of Argentina, Estonia and Lithuania (the AEL model), which surpasses the arbitrage efficiency of the classical currency board and the old gold standard. Unfortunately, it has not been given the attention that it deserves in the literature. There are also proposals involving insurance options issued by the monetary authority that guarantee the fixed exchange rate. The latter actually also aim at eliminating the “systemic risk” of the CBA by committing the monetary authority to an “irrevocable” contract to defend the fixed exchange rate. These alternatives impose additional burdens on the CBA, as well as increasing the “exit cost” from the CBA if it is deemed desirable to abandon the peg.

This paper assesses the CBA as a genre in its historical context and the various alternatives to strengthen it. Hong Kong serves as the central illustration and is contrasted with the AEL model, while Indonesia is used as an example to illustrate some of the pre-conditions for a CBA to be an effective crisis solution. A key conclusion is that a balance has to be struck between the short-term security of a CBA on the one hand, and the long-term consideration of preserving flexibility for the choice of the optimal exchange rate regime in a possible scenario of external crisis, on the other.

1. Introduction

The East Asian economic crisis started out as a currency crisis. Heavy pressures on major currencies in the region began with the Thai baht in mid-1997. Troubles then spread to the Indonesian rupiah, the Malaysian ringgit, the Philippine peso, and the usually robust Singapore dollar. From October 1997 onwards, pressures spilt over to Taiwan, Hong Kong, South Korea and Japan. South Korea subsequently was “rescued” by a huge IMF loan package, so was Indonesia in the midst of its political turbulence in 1998. Indonesia briefly considered the idea of using a **currency board arrangement** (CBA) to stabilize the rupiah, which met with strong opposition by the IMF and the US. Then the Japan yen was again under stress around mid-1998. At stake are the future economic prospects of the East Asian region as a deep recession sets in, and there is no lack of pessimists.

In the fourth week of October 1997, the Hong Kong dollar suffered a powerful speculative attack. Its currency, the Hong Kong dollar (HK\$), has been pegged to the US currency at the rate of HK\$7.80/US\$ since October 1983 under the “linked exchange rate system”, or simply the “link”, which is a peculiar CBA. Although speculators failed to unsettle the link in October 1997, the consequences of its defense, in terms of high interest rates, the plunge in the stock and property markets as well as the emerging unfolding recession, have become increasingly painful. More importantly, the turbulence has raised crucial questions concerning how the exchange rate of the Hong Kong dollar is really “fixed”.

Like the gold standard (Officer, 1989, 1993), “currency boards” were an ingenious invention which in theory relies on the arbitrage activities of self-interested market participants to hold the exchange rate instead of resorting to government manipulation either through (1) foreign exchange control, or (2) market intervention in the form of direct buying or selling of foreign currency by the central bank. Dozens of economies (many former colonies of Britain) adopted the system before the Second World War. There are now about a dozen countries and territories in the world employing variations of CBAs (Schwartz, 1993; Hanke and Schuler, 1994; Williamson, 1995), but ***none in East Asia except Hong Kong*** and the small economy of Brunei.¹

In other words, Hong Kong’s exchange rate system is very different in nature from its neighbors’. It is not supposed to be defended through high interest rates or market intervention by the Hong Kong Monetary Authority (HKMA)---Hong Kong’s central bank, but should be underpinned by a self-adjusting mechanism. Nevertheless, Hong Kong’s experience points to a dilemma: the classical currency board system is facing serious challenges as a result of rapid modern economic developments, particularly in the financial sector. Huge international capital flows throw doubts on whether and how an exchange rate can be fixed without government intervention.

¹ Nominally, Singapore has a currency board that issues notes. However, the board does not fix the Singapore dollar against any single foreign currency; nor does it use cash-based or other forms of arbitrage to protect that exchange rate. See below for the functioning mechanisms of the “genuine” currency boards.

By design or otherwise, several countries including Argentina, Estonia and Lithuania have adopted an extended form of CBA to fix the exchange rate through a more effective employment of the market force, which I have dubbed as the “**AEL model**” (Tsang, 1996a, 1996b). Their modernized arrangement contrasts with the classical version in that arbitrage is no longer based on notes issued by the currency board, but is instead performed electronically through telecommunications among market players. It is a significant improvement not just over the classical currency board, but also compared with the old gold standard where gold bullion had to be shipped around to bring the market rate in line, despite the innovations in related financial instruments (Officer, 1989).

Unfortunately, such a breakthrough in market-based exchange rate fixing has not been given the attention that it deserves. Even informed analyses such as Bennett (1993, 1994, 1995) and Baliño and Enoch (1997) have not highlighted the crucial operational differences between a CBA that only guarantees reserves for currency notes and a new mode that covers bank reserves at the central bank and indeed the whole monetary base, thus allowing for another much more effective channel of arbitrage. That shift is indeed an important qualitative change in recruiting market force to defend an exchange rate by reducing the “**efficiency risk**”.

Nonetheless the AEL model is far from perfect, because it cannot eliminate the “**systemic risk**”: a technically viable system can be given up for political or other economic reasons. Indonesia is an example that a CBA does not seem to be optimal because the systematic risk may be too high. Moreover, external crises could throw any pre-determined exchange rate, including one that is anchored by a CBA, into serious doubt. A big problem is that of “exit”. Proposals that “over-invest” in the fixed rate through insurance instruments under which the authority guarantees to compensate currency holders in case of a surrender (a giving up of the peg) would increase the “**exit cost**” from the CBA. This essay is an attempt to provide a rigorous analysis of merits and setbacks of a market-driven fixed exchange rate regime in the modern context.

2. Classical CBAs: the “tripod”

An exchange rate can be fixed by: (1) foreign exchange controls and/or government interventions in the market; or (2) arrangements that activate self-interested market forces. In many developed economies, the first method has been the norm, whereas market-driven systems include the old gold standard and currency boards. I have long emphasized the distinguishing feature of the latter (Tsang, 1984).

Currency boards actually have a long history, dating back to the 19th century when they were largely adopted in British colonies. The first board was set up in Mauritius in 1849. Eventually, many economies employed similar schemes and the system reached its heyday in the 1940s (Hanke, Jonung and Schuler, 1993; Hanke and Schuler, 1994). In the post-war era, they were out of fashion as newly independent territories sought monetary autonomy by setting up their own central banks, and then floating exchange regimes replaced the Bretton Woods system (Schwartz, 1993; Williamson, 1995).

Currency board economics has been enjoying a revival in recent years. Hong Kong resurrected it in 1983. Then Argentina established a currency-board type scheme in 1991,

Estonia in 1992, and Lithuania in 1994. Because of the emerging varieties, the term “currency board arrangements” (CBAs) has gained wide acceptance. Table 1 shows an update of currency board membership by mid-1997. Other than the three AEL countries, Bulgaria and Hong Kong, all the other CBAs are very small economies with tiny populations. In fact, regarding the crucial aspect of the arbitrage mechanism, the AEL model deviates from the classical currency boards of the colonial era as well as Hong Kong. This is an important point to which I will return with much greater detail below.

Table 1 Existing Currency Board Arrangements (CBAs)

Country/territory	Currency peg	Establishment Year
Argentina	US dollar	1991
Bermuda	US dollar	1915
Brunei	Singapore dollar	1967
Bulgaria	German mark	1997
Cayman Islands	US dollar	1972
Djibouti	US dollar	1949
Eastern Caribbean Central Bank	US dollar	1965
Estonia	German mark	1992
Falkland Islands	Pound sterling	1899
Faroe Islands	Danish krone	1940
Gibraltar	Pound sterling	1927
Hong Kong	US dollar	1983
Lithuania	US dollar	1994

Sources: Williamson (1995), Table 1; Baliño and Enoch (1997); *Monthly Bulletin*, Bulgarian National Bank, various issues.

A currency board issues cash (notes and coins) with 100% foreign exchange reserves backing at a fixed exchange rate against a designated currency (Schwartz, 1993; Williamson, 1995). This supposedly fosters “economic discipline” in monetary and fiscal policies, which would instill confidence and lead to exchange rate stability.

It is far-fetched to argue that an exchange rate can be “fixed” by discipline-generated confidence alone, without practical mechanisms that bind the exchange rate. Technically, a CBA differs from a fixed rate regime based on market intervention. Like the gold standard, it depends on two “automatic stabilizers” to anchor the exchange rate: (1) specie flow and (2) arbitrage.

Under the specie flow process, an outflow of capital, as a result of doubts about the exchange rate, would lead to a contraction of the money supply. The interest rates then go up, and a counter-flow of funds is induced. The series of event would take place automatically and speedily, so that the exchange rate can be “fixed” without government intervention. Such logic seems a bit shaky. Under normal circumstances, interest rate hikes may contribute towards the

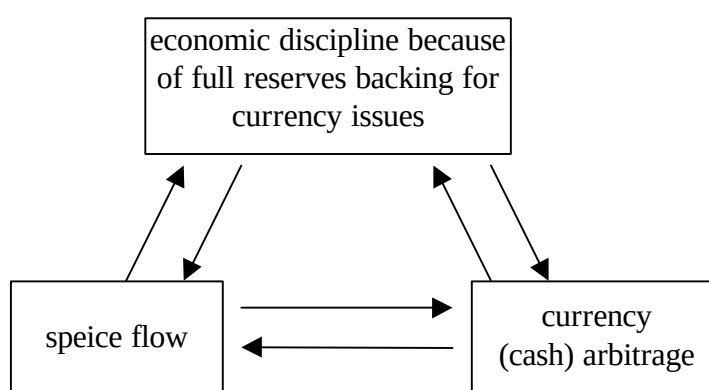
stabilization of a currency. But if the exchange rate is itself fluctuating and looks insecure, higher interest rates will *not* necessarily induce a counterflow of capital. In this sense, the specie flow process is not a reliable mechanism in fixing an exchange rate.

Therefore, there is the need for the second mechanism of the CBA: currency arbitrage (alternatively known as exchange rate arbitrage) that directly binds the exchange rate. Given the board's 100% foreign reserves for cash in circulation, cash arbitrage can be carried out. In case the market exchange rate weakens from the official rate, people can convert their bank deposits into cash, go to the currency board to exchange the cash into foreign currency at the stronger official rate, and then sell the foreign currency in the market. This arbitrage activity will yield a riskless profit, and the selling pressure on the foreign currency will bring the market exchange rate back to the official level (Tsang, 1984).

Under the gold standard, gold bullion was shipped across countries to ensure that exchange rates converged to their gold parities.² In a currency board system, people move currency notes to keep the market exchange rate in line. Both systems appeal to the self-interest of the arbitrageur, and are distinctive from regimes that "fix" the exchange rate through non-market means such as foreign exchange control or buying/selling operations by the central bank.

In general, there are three anchors for a CBA: (1) economic discipline because of the 100% foreign reserves requirement for the issuance of currency; (2) specie flow in the form of interest arbitrage; and (3) exchange rate (cash) arbitrage that binds the spot exchange rate. As illustrated in Figure 1, these three anchors reinforce one another.

Figure 1
The "tripod" for a classical CBA to fix the exchange Rate

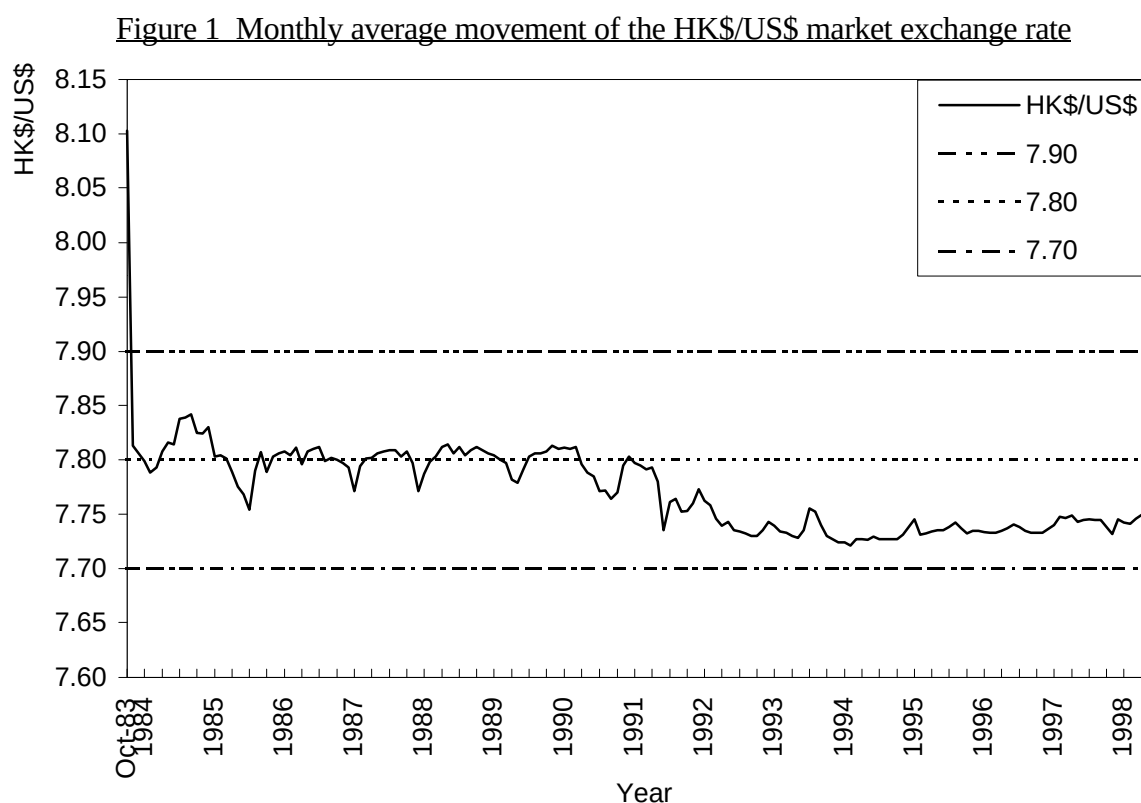


In reality, institutional, policy and macroeconomic drawbacks exist in different CBAs and have prevented the effective functioning of particular anchors. While the Hong Kong CBA has scored well regarding the first two anchors, at least in the 1990s, it is still lacking in arbitrage efficiency, even up to now.

² For a modern analysis of the gold standard, see Bayoumi, Eichengreen and Taylor (1996).

3. The reality of Hong Kong's CBA

Hong Kong's CBA has evolved over the years since October 1983. What is interesting is that it has not functioned in accordance with the theory. There is actually no currency board. While coins are made by the government, notes are issued by a few designated notes issuing banks (NIBs), which alone can deal with the monetary authority at the fixed exchange rate of HK\$7.80/US\$. Notes-based arbitrage opportunities have therefore been highly restricted, rendering one of the two stabilizers almost totally inoperative. It is not surprising that the market exchange rate has strayed from the official rate of 7.80 by an average of slightly less than 1%. In the 1990s, the market rate has been on the strong side of 7.80, which is not necessarily a "good" thing for a "fixed" exchange rate regime.



In the initial period (late 1983-1987), neither economic discipline nor specie flow were depended upon, given the shaky economic and political situation. The presumed bank notes arbitrage process also did not work. The linked rate of 7.80 was held imperfectly, thanks to a combination of government intervention in the foreign exchange market, manipulation of interest rates, and administrative measures (including the legal incorporation of "negative interest rates", when the HK dollar faced the speculative pressure of revaluation in 1987-88). See Nugée (1995) for an official admission.

At that time, the government could not even define the monetary base as banks did not

settle transactions through it. In 1988, the Accounting Arrangements were imposed. That gave the government an indirect handle on the monetary base (notes and coins in circulation plus the clearing balance of the banking system) through the Hong Kong and Shanghai Banking Corporation as the ultimate clearing bank. In the early 1990s, the launching of the Exchange Fund Bills and Notes, as well as the setting up of the “Liquidity Adjustment Facility” (LAF) as a discount window, strengthened the ability of the authority in affecting interbank liquidity in the two-tier system. (Nugée, 1995; Tsang, 1996a, 1996b).

On 1 April 1993, a central bank, the Hong Kong Monetary Authority (HKMA) was formally established by putting all the pieces of reforms under one roof and managed by one powerful institution. Since the 1980s the government had also been successful in accumulating huge fiscal and foreign exchange reserves. These developments and evolving mechanisms enabled the HKMA to modify its stance. Officials were proud to present the link as a currency board system (Latter, 1993; HKMA, 1994). Adequate reserves and economic discipline were emphasized.

Nevertheless, “automaticity” was not on the agenda yet. The HKMA made it known that it would defend the Hong Kong dollar by having flexible ways to manipulate the monetary base and to influence interest rates. Deputy Chief Executive of the HKMA, Andrew Sheng, said on the heel of the Mexican crisis, “ in recent years the HKMA has introduced various reforms to its monetary management tools, or more aptly, our monetary armoury, to maintain exchange rate stability. As was seen in January (1995), our determination to use the interest rate tool was sufficient to deter further speculation against the HK dollar. In fact, currently, the HK dollar is at a stronger level than it was at 1994 year end.” (Sheng, 1995, p.60) “To the extent that the HKMA intervenes through the use of foreign exchange swaps, any increase in the monetary base is fully backed by foreign exchange. We use a whole range of instruments in influencing the level of interbank liquidity to manage interbank interest rates, and consequently, maintain exchange rate stability.” (p.61)

However, under the two-tier Accounting Arrangements, the clearing balance of the banks showed wide fluctuations “because banks on the odd occasion miscalculate their own liquidity position. That is why we need and are developing a new RTGS payment system to manage funds flow more efficiently.” (Sheng, 1995, p.61)

The RTGS (Real Time Gross Settlement) system was installed in December 1996, replacing the previous two-tier structure. The government could then directly manage the clearing balance of the whole banking system (HKMA, 1995, 1997). The HKMA did not make any pronouncements that the link’s mode had undergone any significant changes.

4 Auto-pilot? Developments after the October 1997 attack

In October 1997, the Hong Kong dollar suffered a strong speculative attack, as a result of the “contagion effect” of the East Asian financial turmoil. Doubts were cast on the nature and the robustness of Hong Kong’s CBA. A controversy arose concerning whether and to what extent the HKMA did intervene in the markets on 23 October 1997, and was therefore responsible for the unprecedented high interest rates---with overnight interbank rates going up to 280% at one point.

The HKMA later argued that the Authority was just “sitting there passively”, allowing the system to go on “auto-pilot”. But critics pointed out that the HKMA openly warned banks in the morning of 23 October that those who repeatedly borrowed HK dollars from the LAF would be penalized. This presumably touched off a strong “announcement effect” and banks just scrambled for funds. There were reports that the HKMA also sold US dollars in the market to defend the spot exchange rate of the HK dollar. The result was a further drain in HK dollar liquidity.

In reaction, the Hong Kong government took a major step in defining the link as an automatic CBA. The Chief Executive of the HKMA, Joseph Yam, made an important speech on 3 March 1998 in Japan (Yam, 1998). On 23 April 1998, the Hong Kong government published its report on the October 1997 financial storm: *Report on Financial Market Review* (FSB, 1998). The key change was that *the HKMA announced a commitment not to actively manage the clearing balance of the banking system to defend the exchange rate*. According to the *Report* (FSB, 1998, paras. 3.36-3.41; Annex 3.5), the HKMA would keep to the following rule of automatic adjustment.

“..... In line with the discipline of the currency board system, the clearing balance will be affected by the flow of funds into or out of the Hong Kong dollar. Specifically, when there is an inflow of funds involving the HKMA **passively** buying US dollars sold to it by the banks and providing the Hong Kong dollars, the clearing balance of the banking system will rise. Conversely, when there is an outflow of funds involving the HKMA **passively** selling US dollars and buying Hong Kong dollars from the banks, the clearing balance of the banking system will fall.

The HKMA adheres strictly to this discipline which in effect involves the clearing balance of the banking system varying with the amount of US dollars sold to or brought from the HKMA at the initiative of the banks.” (original emphases) (FSB, 1998, paras. 3.36-3.37)

Although the government did not use the term: it is the “specie flow” mechanism---one of the three anchors of the classical currency board system. So the HKMA chose to abandon the pro-active manipulation of interbank liquidity (the clearing balance) and interbank interest rates as a means of defending the link, and the specie flow process was allowed to unfold naturally. That was *a major policy shift* from past practices. Nevertheless, the HKMA would maintain the option to *sterilize* the monetary effect of several types of “exceptional circumstances”, including

1. Occasions when Initial Public Offerings (IPOs) of shares and other large scale Hong Kong dollar transactions risk creating extreme conditions in the interbank market;
2. The necessity of entering into intraday Repos and overnight Repos (through the LAF) to “smooth the settlement of interbank transactions”;
3. Activities which may have the unintended effects of affecting the clearing balance, such as a transfer of fiscal surpluses by the government to the HKMA.

The HKMA would undertake to neutralize their effects on the clearing balance by recycling or offsetting interbank liquidity through appropriate actions. Note that these are *sterilization measures* to contain domestic shocks rather than international shocks.

In terms of the “tripod” on which a classical CBA relies in fixing its exchange rate (see Figure 1), the HKMA has arrived at a situation where two of three anchors can be effectively used: (1) economic discipline on the basis of adequate reserves; and (2) automatic specie flow. ***The problem lies with the third anchor---exchange rate arbitrage.***

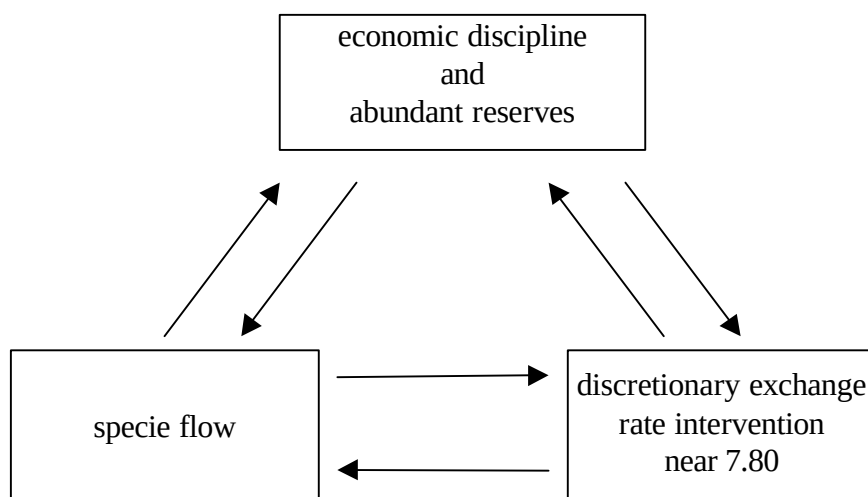
In the *Report on Financial Market Review*, the Hong Kong government admitted the implausibility of bank notes arbitrage---a key pillar of the classical CBA---as an effective mechanism to bind the exchange rate (FSB, 1998, para. 3.34). I have tried to drive home this point for quite some time (Tsang, 1997b, 1998b). To compensate for this deficiency, however, the government did not put in place an alternative arbitrage mechanism, and rejected my proposal (Tsang, 1996a, 1996b, 1997b) of adopting the AEL (Argentina, Estonia, Lithuania) model of convertible reserves under which arbitrage can be performed without involving bank notes or cash (FSB, paras. 3.64-3.65).

Instead, the HKMA has opted for a tactic of “constructive ambiguity” (Yam, 1998, p.24), under which it would manipulate a “surprise element” and choose the level of exchange rate at which it intervenes directly in the foreign exchange market. At the end of 1997, Hong Kong’s international reserves covered more than six times of the currency in circulation. In fact, including the Land Fund, which was transferred to the management of the HKMA in September 1997, Hong Kong had the *third* largest foreign exchange reserves in the world, which represented over 40% of HK\$M3. Hence, the HKMA can afford discretionary market intervention, under which

“....the HKMA will need to decide at which particular level to enter the foreign exchange market to support the exchange rate. This involves judgement by the HKMA as to whether or not the circumstances have become abnormal, for example, when there is speculation.....Furthermore, the intervention level may not be exactly at 7.80, although very close to it. For instance, when there are signs of speculative pressure, the HKMA may establish its presence in the foreign exchange market even though the exchange rate is on the strong side of the link. ” (FSB, 1998, para. 3.43)

As the Hong Kong regime now stands, instead of the traditional tripod of currency board anchorage (Figure 1), the HKMA is relying on a new tripod, as depicted in Figure 2. It is a unique CBA, with the arbitrage anchor replaced by discretionary foreign exchange market intervention to underpin an officially sanctioned exchange rate. Some would even call it “central banking in disguise”.

Figure 2
The tripod for Hong Kong's new CBA



5. Death of the cash arbitrage

As far as currency board economics is concerned, a clear lesson for all from Hong Kong is that cash arbitrage is hopeless in defending a CBA in the modern context. Greenwood and Gressel (1988) detected the problem some time ago; Tsang (1996a, 1996b) tried to tackle it, and then gave up (Tsang, 1997b, 1998b). The *Report on Financial Market Review* put paid to its practicability in Hong Kong (FSB, 1998, para. 3.34). In a banking system with fractional cash reserves, allowing depositors to covert deposits into bank notes for the sake of doing arbitrage is a very hazardous business.

Hong Kong's problems in October 1997 reflected not only its own institutional imperfections, but also the dilemma faced by a monetary authority that tried to apply the principles of the classical currency board to a rapidly evolving financial economy. To put it precisely, ***the classical currency board conflicts with financial developments in the modern world***. In general, moving bank notes around creates special difficulties for a system based on fractional cash reserves for its deposit liabilities. Large-scale withdrawal of bank notes, which account for only about 5% of deposits in most advanced economies, is equivalent to a bank run.

Table 2 shows the progressively diminishing cash base in Hong Kong as the territory became an international financial center. As can be observed, in 1997, for every one hundred Hong Kong dollar deposit in the deposit-taking institutions in the territory, less than one dollar was in the form of notes and coins at hand to entertain withdrawal and related liquidity needs. Banks and other financial institutions simply do not have enough "surplus" notes to perform arbitrage (coins are not admitted because of their trivialities). As to the notes-deposit ratios for the whole economy, the figures actually overstate the importance of Hong Kong dollar currency notes within the territory, as a portion of which has actually been used inside mainland China in the process of the latter's economic reform. The estimate of genuine intra-Hong Kong circulation

at the end of 1997 is only 4.07%, instead of the 5.59%, as reported in Table 2. Appendix B gives the relevant technical details.

Table 2 Cash-deposit Ratios in Hong Kong

	Notes-deposit ratio for the whole economy	Ratio of notes and coins over deposit in all “authorized institutions”
1985	7.60	1.10
1986	7.55	1.14
1987	8.14	1.21
1988	8.15	1.08
1989	8.27	1.22
1990	7.86	1.07
1991	7.70	1.09
1992	8.51	1.31
1993	8.03	0.99
1994	7.32	1.02
1995	6.63	0.88
1996	5.90	0.76
1997	5.59	0.84

Notes: The ratios, in percentages, are year-end ratios. “Authorized institutions” refer to licensed commercial banks and deposit-taking institutions in Hong Kong. For them, no separate statistics for bank notes and coins are provided.

Sources: Census and Statistics Department, *Annual Digest of Statistics*; Hong Kong Monetary Authority, *Monthly Statistical Bulletin*.

Most of the classical currency boards functioned in small colonial economies with a very low degree of financial developments (i.e., systems with very high cash-deposit ratios).³ It was then easy for notes-based arbitrage to take place and to ensure that the exchange rate of the deposit market converges to the official parity. Financial widening and deepening however have led to a progressively shrinking cash base for any economy. To push the argument to its logical, albeit somewhat rhetorical conclusion, the twenty-first century is widely predicted to be a *cashless* society. Then how could a currency board fix its exchange rate by cash-based arbitrage? There will simply be no currency notes around! Shipping gold bullion annoyed few people and involved only a small transaction cost (Officer, 1989), but moving cash around is a different

³ See Appendix C of Hanke, Jonung and Schuler (1993). In the case of some small British colonies, not including Hong Kong, the domestic banks were required to clear their interbank settlements through the Bank of England at the fixed exchange rate. This eliminated the incentive (or actually the ability) for the banks to quote any market rate that deviated from the official one. One can compare such a practice with the AEL model discussed below.

story. That is a definite minus for the classical CBA vis-à-vis the gold standard (Tsang, 1997b, 1998b).

6. The AEL model of convertible reserves

Is there an alternative? One way out is to modernize the CBA and adopt the “convertible reserves mechanism” of Argentina, Estonia and Lithuania (the AEL model), under which interbank exchange rate arbitrage can be performed without involving cash (Tsang, 1996a, 1996b). These three countries began a currency-board type system in 1991, 1992 and 1994 respectively (Baliño and Enoch, 1997). Though latecomers compared with Hong Kong, their improved arrangement has shown a much higher degree of arbitrage efficiency and exchange rate stability, with the spot exchange rate invariably quoted around the official rate, despite political and economic turbulence.

Under the AEL model, banks have an account with the central bank, in which deposit reserves as well as other balances are kept. The central bank guarantees the full convertibility of these bank balances, i.e., the whole monetary base, *at the fixed exchange rate*. This setup bypasses the problem of moving cash around for arbitrage.

Assume that we are in a country adopting the model and the domestic currency “peso” is pegged to the US dollar at parity. Banks are forced to quote the official rate of 1 peso per US dollar. If Bank X deviates by quoting the exchange rate of 1.1 peso, any Bank Y can sell US\$1 million to it for 1.1 million pesos, asking X to transfer the pesos to Y's account at the central bank. At the same time, Y would of course transfer US\$1 million to X's account there. On demand, the central bank would convert the pesos into US\$1.1 million for Bank Y, which then obtains an arbitrage profit of US\$100,000. Bank X, on the other hand, suffers a loss of 100,000 pesos because its US\$1 million at the central bank can only be exchanged into 1 million pesos. If it still does not surrender, it would be vulnerable to much greater losses in the interbank market.

No cash movements are involved, as the central bank plays the role of clearing the arbitrage transactions between the two banks. After settlement, the central bank's foreign reserves will be reduced by US\$100,000. In other words, the central bank risks losing reserves if a commercial bank like X rebels against the CBA. Nevertheless, that loss is matched by a correspondent shrinkage (100,000 pesos) in Bank X's balance sheet. Since the deal is sealed and settled by telephone calls and electronic means, the transaction cost is reduced to a minimum.

In reality, under the convertible reserves system, ***no banks would dare to deviate in exchange rate quotations***. All banks are bound by the rule of the game to quote the official exchange rate, within a very narrow buying and selling spread that truly reflects petty transaction cost, or they will be hit by their market rivals. Hence no actual arbitrage needs to take place, and the central bank will not suffer any loss in reserves. With this improved form of CBA, Argentina, Estonia and Lithuania have been able to literally fix their spot exchange rates despite serious economic or political instability (Tsang, 1996a, 1996b).

Hong Kong can adopt the convertible reserves system to rein in the market exchange

rate. With the RTGS system in place, the HKMA may impose a deposit reserve requirement on the banks. To overcome possible resistance from the banking sector, the ratio, which could be interpreted as a "financial tax", should be as small as possible, and near-market interest rates need to be paid on those reserve deposits. The idea is not to tax the banks, but to ensure that there is suitable liquidity in the reserve account to minimize any possible impact on the interest rate, perhaps in the initial stage. As explained above, if the system works, no actual arbitrage occurs and the spot exchange rate can still be fixed. In that situation of benign equilibrium, the deposit reserve ratio might be very small, even approaching zero. A practical suggestion is to start with a modest 5% ratio (which would already yield reserves much greater than the average of the existing clearing balance) and then revise it downward in the light of the evolving situation.

With huge reserves, the HKMA should have little problem in settling electronic arbitrage among banks at the fixed exchange rate. Adopting the AEL model requires an even lower degree of activism on the part of the HKMA. The Hong Kong economy should face less unpalatable results if the speculators return, as they can see that all the banks are bound by self-interest to quote around the rate of 7.80. In other words, ***speculators have to fight the whole banking system, rather than the HKMA.***

7. Response to the Hong Kong Government's reservations about the AEL model: efficiency risk and systemic risk

This author proposed the AEL model in the consultation exercise of the Hong Kong government after the October 1997 turbulence. The government acknowledged but did not accept the proposal in its *Report on Financial Market Review*, as it regarded the distinction between the monetary arrangements in Hong Kong and those under the AEL model as "relatively minor"---a point on which it did not elaborate (FSB, 1998, para.3.65). In addition, a number of concerns was raised (FSB, 1998, para. 3.44 and para. 3.65):

1. The AEL model "will not protect the economy from the interest rate pain", as a result of speculative attack. Argentina in 1995 was cited as an example of dwindling reserves and high interest rates. Moreover, "since there is no scope for the exchange rate to move, the impact of the flow of funds will fall entirely upon interest rates", thus leading to greater interest rate volatility.

2. There are "transitional problems of moving the exchange rate from the present (strong) level to 7.80".

3. The "proposed statutory reserve requirement will be very unpopular among banks". Moreover, the LAF mechanism has already provided a cushion to sharp interest rate movements.

These legitimate concerns should be analyzed from the appropriate perspective. Of course, when there is an exodus of funds, the government's reserves will contract, even if the exchange rate remains fixed. Moreover, the AEL model cannot eliminate the "interest rate pain". Which system can? Although the spot exchange rate is stable, the forward rate may not necessarily be so if people do not have sufficient confidence in the system. According to the

arbitrage equilibrium equation, local interest rates could still be higher than those of the foreign counterpart, co-existing with weak forward exchange rates for the domestic currency. Nevertheless, such imperfections have logical roots, and it is important to distinguish between two different types of perceived risk: (1) efficiency risk; and (2) systemic risk.

One risk is that market participants are not sure whether the CBA could really “fix” the spot exchange rate. In other words, there is an “efficiency risk” regarding the exchange rate and they demand an interest rate risk premium, inflicting the “interest rate pain”. In an international financial centre like Hong Kong, the efficiency risk cannot be under-estimated as there is no recourse to any form of exchange controls. Anyway, the fixity of the spot exchange rate under an effective arbitrage mechanism over an extended period should lead to a consolidation of confidence, and convergence in domestic-foreign interest rates and spot-forward exchange rates would take place as people dare to engage in interest arbitrage. In the case of the AEL model, such a phenomenon has occurred in Argentina, Estonia and Lithuania, as analyzed by Baliño and Enoch (1997, Appendix I).

The convergence process has however not been perfect in the three countries: local interest rates have still been higher than those of the US dollar (to which the Argentine peso and the Lithuanian litas are pegged) and the German Mark (to which the Estonian kroon is linked). This is due to the existence of “systemic risk”. Although market participants observe the fixity of the spot exchange rate, they are not sure that such a “perfect” system that is working so well will not be abandoned in the future, not because it is defective, but as a result of other economic or political factors. No matter how good it is in anchoring the exchange rate, whether a fixed rate regime is optimal for the economy is always a controversial issue.

Analysts familiar with the situations in the three “AEL” countries understand why some of their people might be nervous, justifiably or otherwise, about the possibility of political instability. Argentina in 1995 (in the aftermath of the Mexican crisis and in the midst of presidential election politics) must be a “perfect” counter-example for the Hong Kong government to cite: it was a time when the systemic risk was so huge. The question can surely be reversed: without the AEL model effectively fixing the exchange rate of the peso against the US\$ at parity, would not the Argentine situation have been even more “disastrous”?

If Hong Kong adopts the AEL model, the efficiency risk should be eliminated rather quickly. Interest rate convergence could unfold at a faster pace than that in those three countries. As to systemic risk, Hong Kong's political and economic situations are far more stable, although re-pegging or re-floating out of optimality considerations can never be ruled out.

Let me return to the specifics of applying the AEL model to Hong Kong. It has already been pointed out that the required reserve ratio could be set at low levels and banks should be paid near-market interest rates, so as to reduce their resistance. With the spot exchange rate locked at 7.80 and quoted by all banks, speculators will have to think very carefully before launching any attack, as they will be playing game with the whole banking system, not just the HKMA. Such hesitation should significantly reduce the pressure on the link, and hence on interest rates through the automatic specie flow process.

The present deviation of the market exchange rate on the strong side of 7.80 is seen by

the HKMA as providing a “scope of adjustment” on top of interest rate movements. Nonetheless, it is small in magnitude (less than 1%) and it is not clear whether it generates a net benefit. Alongside with “constructive ambiguity” (Yam, 1998, p.24) or “the surprise element” (FSB, 1998, para. 3.44), the deviation may actually introduce uncertainty into the system. Whenever the market rate breaches 7.75 now, people will, justifiably or otherwise, regard it as a sign of “weakness” and expect the HKMA to intervene. There is a danger for 7.75 to become a self-imposed defence line if the authority is excessively concerned about the “transitional problems” of moving the market rate to 7.80. Any “surprise element” will then be lost.

The non-alliance of the market exchange rate with the official rate could also have been *the* source of the problem. In the heat of the East Asian crisis, speculators might have regarded the “non-fixity” as a sign of “insecurity” of the link, and therefore decided to have a go at it. If there had been no such deviations, because of say a more robust arbitrage mechanism, speculators might not have come, or might not have been so aggressive.

The key question is whether the combination of automatic specie flow and discretionary foreign exchange market intervention (as depicted in Figure 2 above) constitutes an effective defence of the Hong Kong CBA. A related issue is what the least-cost option is.

8. Should East Asia copy the Hong Kong CBA or the AEL model?

Hong Kong adopted its peculiar CBA in 1983 to solve an “internal crisis”. Indeed, most economies hosting CBAs in the modern context did so for similar reasons. Argentina used the system to end domestic hyperinflation; while Estonia and Lithuania tried it to enhance their fragile new national currencies. One complication is that the “fixed” exchange rate chosen under such a circumstance might not necessarily be appropriate in the long term, particularly if the external environment changes significantly.

As it now stands, the Hong Kong CBA can only be imitated by “strong economies”. Other than Singapore and Taiwan, no other economies in the region have foreign exchange reserves that cover so much of the money supply, and can therefore rely on discretion. This begs the question of why a “strong economy” needs to seek recourse in a rigid fixed exchange rate regime called CBA. In any case, even if a relatively weak economy manages to gather sufficient international reserves, it should not adopt either the classical currency board based on cash arbitrage or Hong Kong’s unique system. The AEL model appears to be the only viable choice. The major concern is that the domestic banking system is at the fore-front of defending the exchange rate under the AEL model. Banks cannot reduce their risk by deviating from the official spot rate, because of the threat of losing money in interbank arbitrage transactions. The impact on them may be quite severe, if there is significant systemic risk. Hence an economy with a weak banking system has to think twice before choosing the AEL model.

The governments in the three AEL countries have tried to contain the market perception of systemic risk through legal means (Tsang, 1996a; 1996b; Baliño and Enoch, 1997). In Argentina and Estonia, it was enshrined in an act of the Congress and the Parliament respectively that the central bank can only revalue but not devalue the exchange rate. In Lithuania, according to the *Law on Litas Credibility* in 1994, the exchange rate could only be

changed by the Bank of Lithuania, in consultation with the government, under extraordinary circumstances.

Enshrining a CBA in law may reduce the systemic risk and lead to an even higher degree of interest rate and spot-forward exchange rate convergence. Nevertheless, convergence will not be perfect as a law is still open to some residual doubts. Moreover, it would increase the exit cost, if it is deemed optimal to abolish the fixed rate regime and re-float the home currency in the future.⁴ Alternatively, in the case of Hong Kong, when all conditions mature some time in the twenty-first century, it may become advisable to peg the Hong Kong dollar to the then freely convertible Chinese currency, the Renminbi, instead of sticking with the US dollar.⁵

The same problem of exit cost also applies to any scheme under which the HKMA issues insurance instruments (e.g. put options) to market participants to foster confidence that the linked rate will not be changed, as well as the proposal of “dollarization”, i.e., replacing the Hong Kong dollar with the US dollar. Compensations could be huge for a permanent insurance scheme, irrespective of its actual contribution to exchange rate stability, which the Hong Kong government expressed strong reservations and doubts in its *Report on Financial Market Review* (FSB, 1998). On the other hand, the re-introduction of a Hong Kong currency could be a troublesome affair after “dollarization”. A balance needs to be struck between the conflicting considerations of “eliminating” the systemic risk for the link and those of reducing the cost of exiting from it.

Can and should other East Asian economies adopt a CBA to stabilize their currencies? Let us look at the example of Indonesia. Although the government has shelved the plan to establish a CBA after strong objections by the IMF and the US, it illustrates the dilemma facing an economy in the midst of a currency crisis. After all, CBAs do have a good record of holding off speculative attacks and keeping the spot rate stable or fixed, although the cost could be considerable. Again, we can assess the issue on the basis of the twin concepts of efficiency risk and systemic risk and ask the following questions.

1. What kind of CBA is Indonesia going to adopt? The classical currency board based on specie-flow and cash arbitrage? Hong Kong’s idiosyncratic version of “linked exchange rate”? Or the AEL model of cashless/electronic arbitrage? In other words, can the Indonesian CBA even keep the spot exchange rate firmly in line? This is the first defense. If it is not

⁴ It is interesting to note that both Estonia and Lithuania have started the process of applying to join the European Economic and Monetary Union (EMU). A pre-requisite for eventual membership means that they have to give up their CBAs, no matter how perfect they are, because the EMU hosts a central banking system. Lithuania has actually announced that it is exiting from their CBA in stages during 1997-99. See Bank of Lithuania (1997), *The Monetary Policy Programme for 1997-99*. This shows the importance of considering the issue of exit cost for CBAs.

⁵ An example will illustrate the simplicity of such a scenario of currency realignment. Suppose we are in a period when the exchange rate of the freely convertible Renminbi against the US\$ has stayed at and is expected to continue to be around Rmb7.80/US\$ for some time, and the HKMA decides that the HK\$ should be linked to the Renminbi instead of the US\$. Given the linked rate of HK\$7.80/US\$, the HKMA can declare that the link is changed to HK\$1.00/Rmb1.00. This “horizontal” change of track will have no implications with regard to foreign exchange gains or losses for any party involved, **at the time of the realignment**. Further down the road, it will be up to every one to make the necessary adjustments, should the Rmb/US\$ exchange rate fluctuate.

secured, the following, second, question would be irrelevant. It appears that the country should choose the AEL model of convertible reserves, which binds the whole banking system through electronic arbitrage to quote narrowly around the official exchange rate. But is the Indonesian banking system ready for the model, in terms of hardware and software, as well as its financial viability at the pegged rate eventually chosen?

2. Granted that the Indonesian CBA, whatever form it takes, can hold the spot exchange rate of the rupiah firmly through an efficient arbitrage mechanism, hence eliminating the efficiency risk, how could it inspire confidence in market participants that the CBA (especially regarding the specific fixed rate of the rupiah against the designated anchor currency---the US dollar) would not be abandoned in the future, out of economic or political considerations? This constitutes a systemic risk which must be carefully addressed, with a view to balancing short-term stability concern and long-term exit cost calculation.

9. Internal versus external crises: exit cost

In sum, despite the remarkable record of CBAs in defusing internal crises, as the experiences of Hong Kong, Argentina, Estonia and Lithuania have demonstrated, not all economies could save their exchange rates via this route. “Bank soundness” (Santiprabhob, 1997; Tsang, 1998a) and the containment of “efficiency” and “systemic” risks are legitimate concerns (Tsang, 1998a; 1998b). In any case, even if a CBA can solve short-term internal crises, its long-term desirability as an economic institution remains an open question. It is useful to distinguish external from internal crises.

In theory, the more flexible the real sector of an economy is, the more suitable is a fixed exchange rate to it, as the real economy will adjust quickly, without having to go through nominal and relative price changes via exchange rate movements. For a *small open economy* with a huge financial sector, a floating exchange rate system may bring instability, as it will be difficult to contain speculative capital movements and attack on the currency. A fixed exchange rate regime, especially a CBA that commands credibility, does have the advantage of diverting pressure away from the exchange rate to other aspects of the economy and thus providing an anchorage.

The problem is that a CBA in the modern context often provides an anchorage for a desperate economic “ship” in a rough sea, and the arrangement may not have been well planned for uncertainties beyond the immediate horizon. While a CBA requires “strict” fiscal and monetary discipline, it does not serve as a very good barometer of imbalances that might be building up in the economy. Bubbles could emerge, as in the case of Hong Kong (Tsang, 1998a), and the consequences would be very serious if the fixed exchange rate collapses under pressure, as testified by the experience of several East Asian economies.

As a very strong form of fixed exchange rate regime, a currency board system may find it hard to deal with major external crises, structural divergence and deep-seated economic imbalances that do not show up easily. The difference between internal and external crises is crucial in the assessment of the economic optimality of a CBA. Unfortunately, this is a neglected topic in the debate of fixed versus floating exchange rate, as well as in the discussion about

currency board economics. A key issue relating to that difference is the exit cost of quitting a peg. If more is invested in building confidence in the system, more has to be foregone when it is finally deemed necessary to abandon the ship because the external crisis is generating such lethal consequences for the local economy. A balance needs to be kept over the conflicting considerations of ensuring short-term stability and of maintaining long-term flexibility.

10. Concluding remarks

The Hong Kong link is a very different animal compared with the other exchange rate regimes in its East Asian neighbors. At the same time, though, the link is a "black sheep" in the camp of the currency boards, because of historical tradition, deep-seated contradictions between the currency-board ideals and modern financial reality, as well as policy choices. The HKMA has chosen to use "non-classical" means to defend the Hong Kong dollar, including central banking and market intervention. Since re-floating and re-pegging are not viable options under the present circumstances, the only viable alternative for Hong Kong is to move forward to a system of more efficient arbitrage in fixing the exchange rate, i.e. the AEL model, rather than to return to the nostalgic classical currency board that relied on cash arbitrage.

Economic fundamentals cannot fix an exchange rate for long. Mobilizing self-interested market activities can. On the other hand, fixing the exchange rate does not automatically solve all economic problems. Ills in the economy will manifest themselves one way or the other. If the exchange rate does not adjust, other economic variables will have to. This is just common sense. The economies of Argentina, Estonia and Lithuania have not been in very good shape. However, at least they do not have to worry about the exchange rate. Their efficient arbitrage mechanism diverts pressures to other aspects of the economy.

In a wider context, the AEL model represents a development that is worthy of serious attention, beyond the mainstream discussions on currency board economics. Unlike the old gold standard and the classical currency board, no physical movement of gold bullion or bank notes is required, and the transaction cost of performing "electronic" or "cashless" arbitrage is reduced to an absolute minimum. As a result, arbitrage efficiency is maximized and the spot exchange rate can be fixed by directly harnessing the self-interest of the arbitrageur. Commitments to a fixed exchange rate through sufficient backing of international reserves and compliance to other forms of economic discipline, as well as the automatic specie-flow adjustments via balance of payments and interest rates, are important factors to the maintenance of CBAs. Nevertheless, at the end of the day, if the spot exchange rate is not anchored at the fixed level continuously, confidence cannot be built up. Existing literature has unfortunately neglected this vital point.

In their introduction to a volume on modern perspectives on the gold standard, Bayoumi, Eichengreen and Taylor (1996, p.4) give the following interesting remarks:

"The pre-1914 gold standard that prevailed over much of the world is an obvious challenge to the notion that open capital markets are incompatible with stable exchange rates and international economic relations. Between 1879, when the United States rejoined the system after its Civil War, and the outbreak of the Great War in 1914 the currencies of the major industrial countries were

convertible by law into fixed quantities of gold, and bilateral exchange rates were fixed to bands of roughly plus or minus one half of 1 percent through arbitrage in private markets. The fixed gold parities and stable bilateral exchange rates they implied were maintained for a period of decades despite the absence of controls on capital flows and the presence of high international capital mobility. For those concerned with the implications of financial liberalization for economic policy in general and exchange rate policy in particular, the gold standard therefore continues to be of relevance and interest."

Given the even higher arbitrage efficiency on the part of the AEL model, and the fact that no physical constraints in the form of gold or cash are imposed on the system, it certainly is of at least equal relevance and interest to economists in the field of international monetary economics and deserves much closer scrutiny. This paper hopefully provides a motivation for more in-depth analysis that integrates modern perspectives on the problems of efficiency risk, systemic risk, and exit cost, as well as the difference between an internal crisis and an external crisis.

APPENDIX A Credibility Tests on the Hong Kong Link

Svensson's (1991) "simplest test" of the target zone credibility is performed on Hong Kong's linked exchange rate system. The rationale is that, because of arbitrage imperfection, the market rate would deviate to a certain extent from the official rate of HK\$7.80/US\$. Nevertheless, the system still holds as market participants do not doubt its ability to continue, albeit at some cost. Svensson's test starts by computing the rate of return of a foreign currency investment for t months, R_t^τ , given a band within which the central bank defends the exchange rate. Hence there will be an upper bound ($\bar{R}_t^\tau$) and a lower bound ($\underline{R}_t^\tau$) of the rate of return. The upper bound is calculated as:

$$\bar{R}_t^\tau = (1 + i_t^{*\tau})(\bar{S}/S_t)^{12/\tau} - 1$$

where $i_t^{*\tau}$ represents the foreign interest rate in time t for a τ -month loan or investment, S_t the spot exchange rate (expressed as the ratio of the domestic currency per unit of foreign currency), and $\bar{S}$ the upper bound of the exchange rate (i.e. the limit of depreciation allowed). Likewise, the lower bound of the rate of return is given by

$$\underline{R}_t^\tau = (1 + i_t^{*\tau})(\underline{S}/S_t)^{12/\tau} - 1$$

Under the assumption of there being no arbitrage, a completely credible exchange rate implies that the domestic interest rate i_t must lie within the band of R_t^τ , i.e.

$$\underline{R}_t^\tau \leq i_t \leq \bar{R}_t^\tau.$$

If the domestic interest rate moves above the upper bound, the no-arbitrage assumption implies that the exchange rate regime cannot be completely credible as investors perceive a risk

of devaluation. A 1% limit on either side of 7.80 as the range of the "target zone" for the linked rate system is used, on the basis that the government did seem alarmed when the deviation from the official rate approached 1% in the past. Hence $\bar{S}$ is 7.878 and $\underline{S}$ is 7.722 for the zone. But it should be pointed out that the HKMA has never explicitly defined any "target zone".

Figure A1 shows the results using *monthly average* figures. Three-month domestic interest rate (Hong Kong interbank offer rate---HIBOR) is used as i_t^3 and three-month Eurodollar interest rate is employed as a proxy for $i_t^{*\tau}$. It can be observed that in two periods the credibility of the linked rate system was in doubt:

1. Summer 1984: before the Sino-British agreement on the future of Hong Kong (which was signed in late 1984), when political jitters still caused confidence problems;
2. Late 1987: when speculation about a possible re-valuation of the HK\$ against the US\$ significantly strengthened the HK\$ market rate, against which the government had to legalize "negative interest rates" (*a la* Switzerland) on HK\$ deposits, other than resorting to massive intervention in the foreign exchange market.

Another variant of Svensson's (1991) test using the assumption of uncovered interest parity is also performed. Let us look at the following equation:

$$E_t S_{t+\tau} = S_t [(1 + i_t^\tau)/(1 + i_t^{*\tau})]^{1/12}$$

where $E_t S_{t+\tau}$ is the expected value in time t of the ruling exchange rate in month $t + \tau$. The right-hand side of the equation is the (annualized) interest differential (between the domestic and foreign interest rates) adjusted for the maturity period of τ months. It can be checked whether the expected exchange rate (determined by interest differential) ever moved outside the "target zone", i.e. $\bar{S}$ and $\underline{S}$. Again, the three-month case is investigated and the results are shown in Figure A2. The findings are similar to that of Figure A1.

The above analyses use monthly average figures, which tend to smooth out volatility and lend "credibility" to any exchange rate system. The currency attack on the Hong Kong dollar in late October 1997 occurred within a very short time frame. Interest rates went up to unprecedented levels on 23 October 1997, then came down rather rapidly, although to levels that were still markedly higher than those before the attack. Hence I have implemented another exercise of the two variants of Svensson's test using *daily closing data* running from January 1997 to mid-July 1998. The results are presented in Figures A3 and A4. In contrast to the tests using monthly average data, they show clearly that the link was not "credible" in face of the currency attack in late October 1997, given the 1% target zone. Market participants at that time obviously suspected that the Hong Kong dollar would devalue. Two more sub-attacks occurred in January 1998 (because of the Indonesian crisis) and June 1998 (as a result of the pressure on the Japanese Yen). Under both occasions, the credibility of the link was breached, albeit to a much lesser extent than the first attack.

Figure A1 Svensson's "simplest test" on the link using monthly data (no arbitrage)

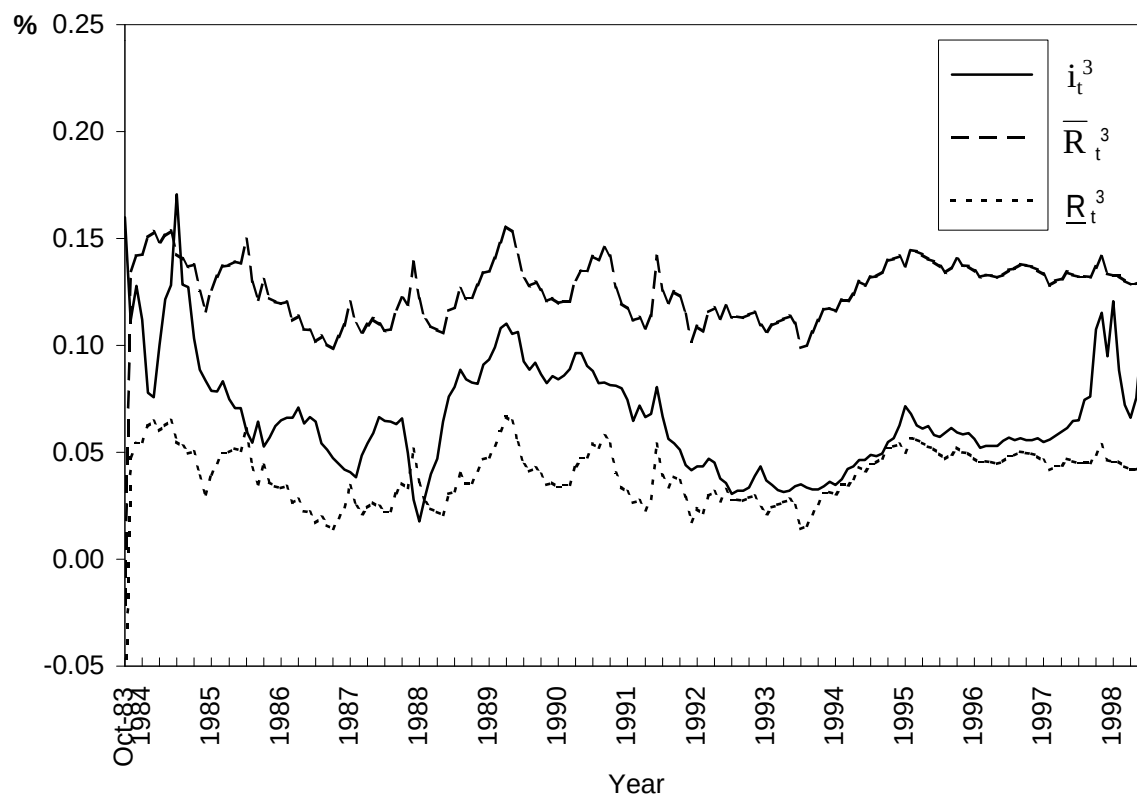


Figure A2 Svensson's "simplest test" on the link using monthly data (uncovered interest parity)

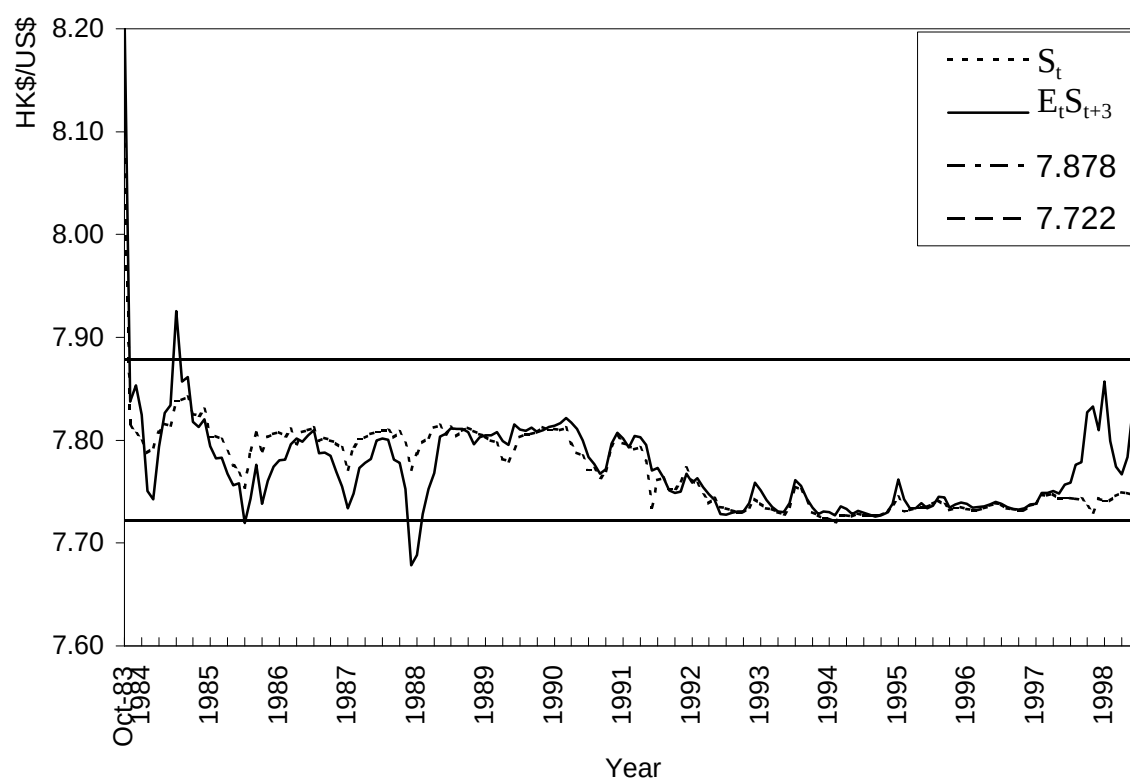


Figure A3 Svensson's "simplest test" on the link using daily data (no arbitrage)

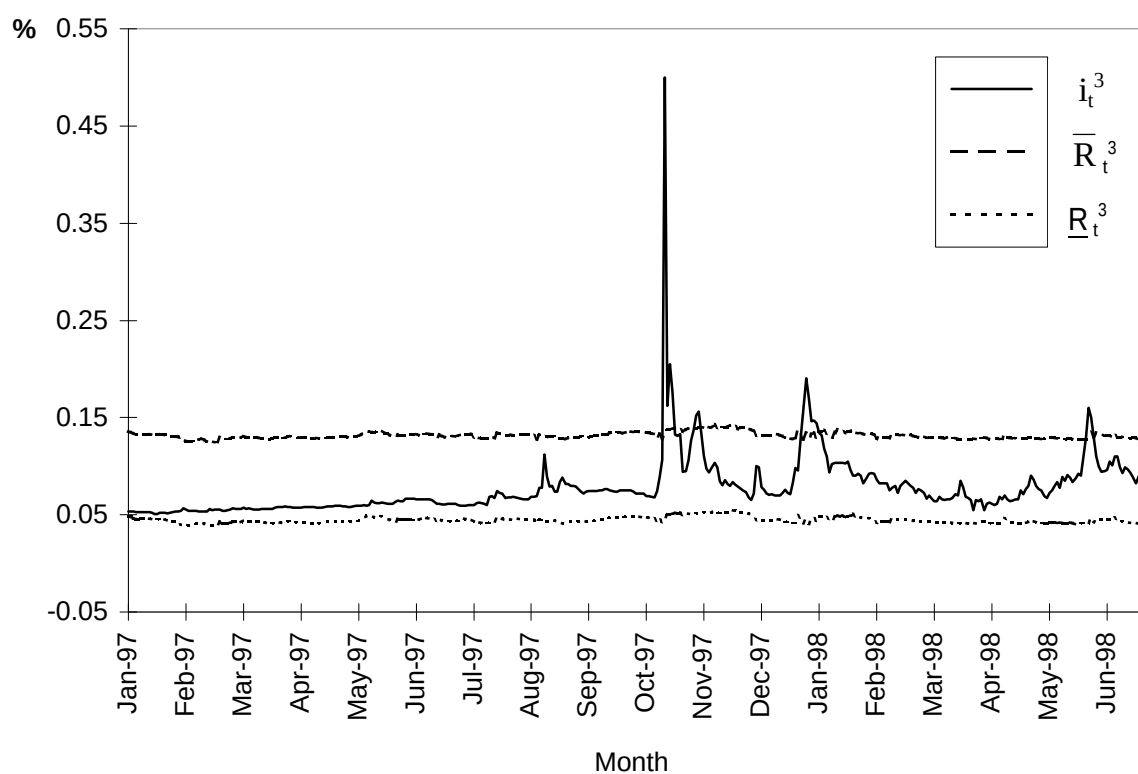
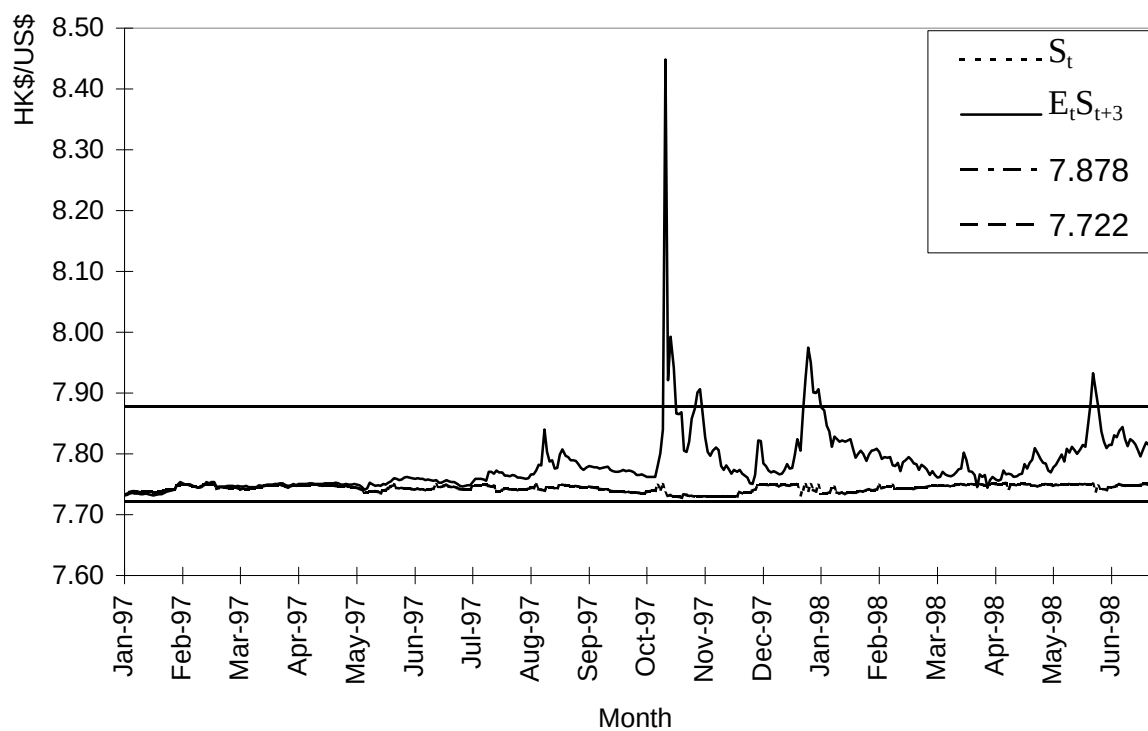


Figure A4 Svensson's "simple test" on the link using daily data (uncovered interest parity)



APPENDIX B Hong Kong Dollar Currency Notes: Domestic and Extra-territorial Circulation

One complication about the currency in circulation in Hong Kong is the spread of HK\$ notes to southern China after 1978, when the country launched its economic reform. Following *Asian Monetary Monitor* (1990), we model the normal pattern of currency-to-GDP (C/GDP) ratio in Hong Kong as the economy matures. Any "above normal" amount of currency in circulation may then be interpreted as extra-territorial demand, mainly circulation of HK\$ in southern China. Recent international experience shows that a currency-to-GDP ratio of about 4% is a norm for a "mature" economy. We first fit various equations of the form

$$Y = a + b/X^n$$

where Y is the actual currency-to-GDP ratio over the years, a is constrained to 0.04, and X is a time trend variable. As X becomes larger, b/X^n will approach zero. Y will then come close to 0.04. The equation

$$Y = 0.04 + b/X^{6.1}$$

gives the best fit for the period of 1966-1983. The R^2 statistic is 0.9220. The equation is then used to extrapolate the value of Y for 1985-1997. The fitted values of Y in those years represent what the currency-to-GDP ratios should have been in Hong Kong, if there had been no extra-territorial circulation of HK\$ currency in mainland China in those years. Table B1 summarizes the simulation results.

Table B.1 Estimates of HK\$ currency circulating in China

	(1) Actual C/GDP (%)	(2) Fitted C/GDP (%)	(1)-(2) Extra-Hong Kong C/GDP (%)	Estimate (HK\$ million)
1985	6.61	5.98	0.63	1725
1986	6.60	5.84	0.76	2371 (37.5%)
1987	7.00	5.71	1.29	4959 (109.2%)
1988	6.99	5.60	1.40	6363 (28.3%)
1989	7.12	5.49	1.63	8538 (34.2%)
1990	7.02	5.39	1.63	9499 (11.3%)
1991	6.96	5.30	1.66	11104 (16.9%)
1992	7.47	5.21	2.26	17621 (58.7%)
1993	7.68	5.13	2.55	22845 (29.7%)
1994	7.36	5.06	2.30	23265 (1.8%)
1995	7.21	4.99	2.22	23890 (2.7%)
1996	6.92	4.93	1.99	23749 (-0.6%)
1997	6.69	4.87	1.82	24399 (2.7%)

The estimated amount of HK\$17.6 billion for the year of 1992 is close to that of HK\$15 billion of Yam (1994), which does not specify the exact year to which his estimate applies. Circulation of HK\$ notes in mainland China seems to have stabilized since, which is consistent with the progress that China has made in achieving current account convertibility for her currency, the Renminbi (Tsang, 1997a). Given our estimate of the extra-Hong Kong circulation of HK\$ notes, the notes-deposit ratio within Hong Kong at the end of 1997 would have been 4.07%, instead of 5.59% as reported in Table 2 in the main text.

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