

Modern Currency Boards as Embedded Options

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Abstract

In this paper, we discuss the evolution of Hong Kong’s currency board (CB) from a classical arrangement to a modern CB by introducing two-way convertibility undertakings (CUs) with a spread to cover the whole monetary base. With hindsight, and noting Krugman (1991), we find that (1) two-way convertibility undertakings (CUs) are essentially the striking prices of the put and call options, and (2) the two combined options are implied in the CUs for every dollar in the monetary base: a put option on the weak-side undertaking, and a call option on the strong-side undertaking. The embedded-options framework apparently addressed the problems of the alternative arrangement that relies on issuing explicit options by the monetary authority with ambiguous size and maturity to undefined potential buyers.

1. Introduction

In 1997-98, the Hong Kong dollar was under severe speculative attack. The so-called classical currency board system adopted since 1983 adopted the “fixed rate” of HK\$7.80 per US dollar as a nominal anchor (Yam, 1999). However, the formal government guarantee of HK\$7.80/US\$ only covered note issuance and withdrawal. The guarantee became increasingly trivial as bank notes occupied a very small percentage of the monetary base in an international financial centre like Hong Kong, not to mention the broad money supply. As result, the theoretical argument to maintain the fixed HK\$ exchange rate in a classical currency board by cash arbitrage was very weak. The Hong Kong government had to rely on frequent market interventions in the foreign exchange market to push the Hong Kong dollar to approach the 7.80 level (Tsang, 1999a, b). The linked exchange rate experienced a severe attack when speculators took the advantage of the vulnerability of the system and engaged in a double-play in both the foreign exchange and stock markets of Hong Kong during the Asian financial crisis in 1997-1998. The speculators borrowed large amounts of HK dollar, then short-sold stocks and Hang Seng Index futures before shorting the Hong Kong dollar. Their relentless sell-off of the HK dollar spiked the interest rate, which in turn aggravated the stock exchange. The Hong Kong government had to intervene heavily in both the foreign exchange and stock markets to defend the exchange rate system and the economy (Tsang and Ma, 2002).

After initial academic consultations in the midst of the crisis, the Hong Kong Monetary Authority (HKMA) implemented a one-way convertibility undertaking on the weak side

at HK\$7.80/US\$ for the whole monetary base, which was part of the proposal put forward by Tsang (1999a). On May 18, 2005, a strong-side convertibility undertaking by the HKMA was also introduced to commit it to buy US dollars from licensed banks at HK\$7.75/US\$, and shifted the weak-side convertibility undertaking from 7.80 to 7.85, so as to achieve a symmetry around the pre-defined central parity of HK\$7.80/US\$. This completes the transition of Hong Kong's currency board from a classical version to a modern system.

In this paper, we examine the idea that the current modern currency board arrangement in Hong Kong is effectively based on embedded options without maturity. Convertibility undertakings (CUs) are striking prices of options: a put option on the weak side of the CU, and a call option on the strong side.

The remaining of the paper is organized as follows. Section 2 discusses the two-way convertibility undertakings by the HKMA since 2005. Section 3 explains why convertibility undertakings are striking prices of options. Section 4 points out that modern currency boards are essentially embedded options. Finally, Section 5 concludes.

2. Two-way convertibility undertakings by the HKMA since 2005

To strengthen the linked exchange rate system, the Hong Kong Monetary Authority (HKMA) carried out academic consultations for reform proposals in the midst of the Asian financial crisis. Notable proposals include issuance by Hong Kong government of

explicit HK\$ put option suggested by Merton Miller from the University of Chicago. The problems of this proposal are the ambiguity of the volume of the option to be issued, its maturity and market pricing, and the uncertainty who should be the potential buyers.

Shu-ki Tsang from Hong Kong Baptist University put forward a distinct proposal of two-way convertibility undertaking for the monetary base of a modern central bank with a “hard fix” intention, following the AEL (Argentina, Estonia and Lithuania) model (1999a), which bypassed the problems in Miller’s proposal.

A convertibility undertaking (CU) is effectively an embedded option, covering the monetary base of the central bank (i.e., all its liabilities). With hindsight, the beauty of the AEL model is that the problems inherited in Miller’s proposal disappear. The whole banking system serves as the buyer. The size of the option is the whole monetary base. The option has striking price at the CU and no maturity is implied. Furthermore, there is no need to worry about manipulation of the market price of the issued option, not in any explicit way.

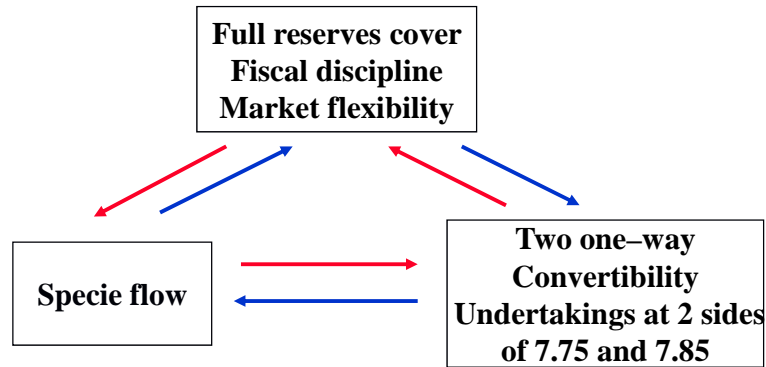
Initially, the HKMA only adopted a one-way convertibility undertaking on the weak side at HK\$7.80/US\$. The major consideration was that revaluation pressure seemed rather irrelevant in the crisis. Nevertheless, the situation changed in 2004-2005. The persistent high growth of the Chinese economy generated expectations of revaluation of her currency renminbi and the HK dollar was served as a proxy due to geographical and economic closeness. Without a CU on the strong side of HK dollar, speculations to long HK dollar

piled up the aggregate balance of the banking system in Hong Kong to an abnormally high level.

On May 18, 2005, the HKMA introduced the three refinements (三項優化措施): (1) a strong-side convertibility undertaking by the HKMA to buy US dollars from licensed banks at the fixed rate of HK\$7.75/US\$, (2) the shifting over 5 weeks of the existing weak-side convertibility undertaking by the HKMA to sell US dollars to licensed banks from 7.80 to 7.85, so as to achieve symmetry around the pre-defined central parity of 7.80, and (3) within the zone defined by the levels of the convertibility undertakings (the ‘convertibility zone’), the HKMA may choose to conduct market operations consistent with currency board principles. These market operations should be aimed at promoting the smooth functioning of the Linked Exchange Rate System, for example, by removing any market anomalies that might arise from time to time (Houston, Lin, and Ma, 2012).

With these three refinements, the latest currency board system in Hong Kong is depicted in Figure 1.

Fig 1. HK's CB since May 2005



Basically it instituted a reserves system whereby each bank had an account with the central bank, in which any reserves for notes and deposits as well as the clearing balances were kept. The central bank guaranteed the full convertibility of all the claims of each bank, *at the fixed lower and upper bounds of the exchange rate.*

In effect, *the convertibility undertakings (兌換保證) covers the whole monetary base (整個貨幣基礎)*, i.e., essentially all the domestic liabilities of the central bank, and not only cash. This set-up bypassed the problem of moving cash around for high-cost cash arbitrage in the classical currency board systems of the colonial period.

Under such a system, no banks would dare to quote an exchange rate outside the official band, say 7.85. Let's use a counterfactual example to illustrate this point. If Bank A quoted

a rate of 8.00, Bank B could immediately sell US\$ 1 million to it, fetching HK\$ 8 million, with an instruction that Bank A transferred the amount to its account at the central bank, which would convert HK\$8 million into US\$ 1.019108 million for Bank B at the fixed rate of 7.85. A profit of US\$19,108 then went to Bank B. Other banks would also be jumping at the arbitrage opportunity if Bank A insisted in not changing its loss-making quote.

Note that *no* cash movements are involved in all these *electronic transactions* (電子交易), as the central bank plays the role of settling arbitrage activities between banks by providing the necessary foreign reserves. The market exchange rate could only deviate from the official rate for the small amount of transaction costs involved, if at all.

With this improved currency board system, Hong Kong dollar spot rate was able to ensure 100% stability within the announced band set by the HKMA. The market speculations to revalue the Hong Kong dollar following the suit of renminbi disappeared fairly quickly after a strong side of CU was imposed by the HKMA.

3. Convertibility undertakings as striking prices of options

With hindsight, and noting Krugman (1991), we find that (1) two-way convertibility undertakings (CUs) are essentially the striking prices of the put and call options, and (2) the two combined options are implied in the CUs for every dollar in the monetary base: a put option on the weak side of CU, and a call option on the strong side.

Hong Kong's current linked exchange rate system, with a width of 1,000 pips between 7.75 and 7.85 since May 2005, in a way resembles a target zone (Krugman, 1991). The important difference is that the strong and weak sides are buttressed by explicit convertibility undertakings, which will be automatically triggered. In Krugman's original formulation, even the genuine commitment of the central bank to defend the zone is subject to speculative tests (Tsang, 2010).

Krugman (1991) describes the defense by the central bank on both sides as similar to "smooth pasting" in the theories of option pricing and irreversible investment:

$$s = m + v + \gamma E[ds]/dt$$

where s is the log of the spot price of foreign exchange (i.e., an increase in s is a depreciation of home currency), m is the money supply, v the velocity shock, and $E[ds]/dt$ is the expected rate of depreciation.

In Krugman's set-up, the S-shaped curve of target zone solution is obtained by the active interventions of the central bank without explicit convertibility undertakings.

Now we adapt the options theory to Hong Kong's situation, which has explicit convertibility undertakings on both sides of the convertibility zone. Instead of relying on central bank interventions on both edges of the zone, the CUs are triggered. With exactly the same expectations that the spot exchange rate s is to be contained within the zone, the option pricing solution is therefore the same as the one found by Krugman (1991):

$$s = m + v + A(e^{\rho v} - e^{-\rho v}),$$

where $\rho = \sqrt{\frac{2}{\gamma\sigma^2}}$.

A and \bar{v} are obtained by solving the following two simultaneous equations (Krugman, 1991):

$$\bar{s} = \bar{v} + A(e^{\rho\bar{v}} - e^{-\rho\bar{v}})$$

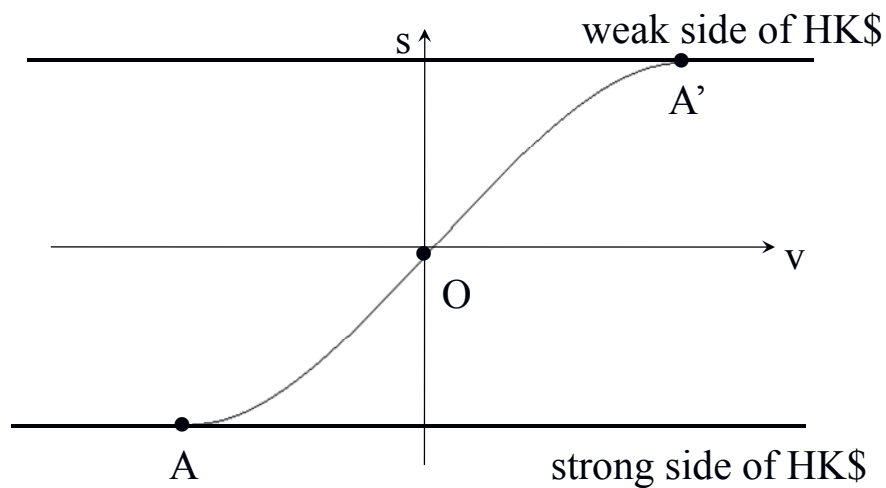
and

$$0 = 1 + \rho A(e^{\rho\bar{v}} + e^{-\rho\bar{v}}).$$

where \bar{v} is the value of v at which s rises to the weak side of the band.

This S-shaped curve of option pricing is depicted in Figure 2.

Fig 2. Option pricing solution



A, A': CU triggered under persistent $v < 0$ and $v > 0$, respectively

4. Modern currency boards as embedded options

In 1997-1998, academics, analysts and policy makers in Hong Kong argued about how to defend the link. Tsang's (1999a) proposal was the AEL model, with an explicit CU for HK\$7.80/US\$ for the whole monetary base. Others, including Merton Miller of the University of Chicago, suggested explicit options (with tentative views about the size and the buyers); while the idea of dollarization was also raised by some academics (Tsang, 2010).

We can now drive home the point that CBs can be instituted as *embedded* options for the whole monetary base. If a spread is required, e.g., in an IFC like Hong Kong, then separate put and call options are required. The *explicit* striking prices are the two CUs. They are issued to all counter-parties of the liabilities of the HKMA, with no defined maturity. There are *no* administrative or transaction fees for reversal. Given a spread between the two options, their *implicit* market prices are reflected in the HIBOR and the market exchange rate of HKD within the convertibility zone of [7.75, 7.85], as investors and speculators take up different positions. If history is any guidance, their strategies have more been to gain marginal value rather than to challenge the CUs. *Hence CBs using embedded options via CUs may be superior.*

5. Conclusion

In this paper, we discuss the evolution of Hong Kong's currency board (CB) from a

classical arrangement to a modern CB by introducing two-way convertibility undertakings (CUs) with a spread to cover the whole monetary base. With hindsight, and noting Krugman (1991), we find that (1) two-way convertibility undertakings (CUs) are essentially the striking prices of the put and call options, and (2) the two combined options are implied in CUs for every dollar in the monetary base: a put option on the weak side of CU, and a call option on the strong side of CU.

The embedded-options framework apparently addresses the problems of the alternative arrangement that relies on issuing explicit options by the monetary authority with ambiguous price and maturity to undefined potential buyers. So far, the CUs in Hong Kong have proved to be robust against the collapse of Argentina's currency board, the persistent revaluations of the renminbi, the recent financial tsunami, and the European sovereign debt crisis since late 2008.

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