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An Analytical Framework for the Hong Kong Dollar Exchange Rate Dynamics under Strong Capital Inflows

Prepared by Matthew S. Yiu and Wai-Yip Alex Ho
Research Department

Yue Ma
Lingnan University

Shu-Ki Tsang
Hong Kong Baptist University

Abstract

Between the fourth quarter of 2008 and the end of 2009, the strong-side Convertibility Undertaking was triggered repeatedly with remarkable capital inflows into the Hong Kong dollar. In view of this development, this paper proposes an analytical framework to understand the relationship between a two-sided target zone regime and equity market. The framework features non-trivial portfolio choices among risk-free bonds and risky assets offered in the domestic and foreign economies, where the exchange rate between the two economies is managed through a two-sided target zone regime. Our simulation results show that the equity-return differential between the two economies serves as a counter-balance factor of the risk-free interest-rate differential in determining the movements of the exchange rate.

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Keywords: Hong Kong dollar, target zone, uncovered interest rate parity, capital inflows

Authors' E-Mail Addresses:
msfyiu@hkma.gov.hk, awyho@hkma.gov.hk, yuema@ln.edu.hk, sktsang@hkbu.edu.hk

EXECUTIVE SUMMARY:

- *Between the fourth quarter of 2008 and the end of 2009, the strong-side Convertibility Undertaking (CU) was triggered repeatedly with remarkable capital inflows into the Hong Kong dollar. Furthermore, the forward exchange rates in particular at the 12-month tenor persistently fell outside the Convertibility Zone, with the rates stronger than the strong-side CU of 7.75. In view of these developments, this paper proposes an analytical framework, which allows us to understand the possible causes of these market movements in the absence of any apparent doubt about the credibility of the Linked Exchange Rate system.*

- *Since the local equity market offered high rates of returns for overseas investors, the proposed framework allows non-trivial portfolio choices between risk-free monetary assets and risky equities. In the framework, the Hong Kong-dollar exchange-rate movements depend on both the changes in the equity-return differential between Hong Kong and the US, and in the interest-rate differentials. The equity-return differentials make the exchange-rate dynamics more sensitive to the underlying movements of economic fundamentals than implied by conventional target zone models that do not take into account portfolio allocation into risky assets.*

- *The simulation result using the proposed framework shows that a 1% narrowing between the returns on equities in Hong Kong and the US weakens the Hong Kong dollar by 300 pips. An increase in the Hong Kong-dollar interest rate can act as a counter-factor but it requires a significant increase in order to overcome the effect from the equity market.*

- *On the other hand, we find that the one and two percentage-point increases in the US-dollar interest rate with no change in the Hong Kong-dollar interest rate will weaken the Hong Kong dollar by about 60 pips and 160 pips respectively.*

- *The simulations of the "double hits" scenarios show that a 1% narrowing of the equity-return differential together with the one and two percentage-point increases in the US-dollar interest rate over the Hong Kong counterpart will cause the Hong Kong dollar to depreciate by about 470 pips and 540 pips respectively.*

I. INTRODUCTION

The Hong Kong Monetary Authority (HKMA) introduced the three refinements to the Hong Kong Linked Exchange Rate system (LERS) in May 2005. Since then the LERS has been operating under a target zone regime. Several studies have reviewed the operations of the LERS to better understand interest-rate and exchange-rate dynamics after the reform.[1] In particular, Genberg, He and Leung (2007) summarise that a fully credible exchange-rate target zone regime should exhibit the following characteristics:

(i) The spot exchange rate normally does not touch the Convertibility Undertakings (CUs), as market expectation of intervention by the HKMA at the limits will stabilise the market exchange rate. The spot rate does not necessarily have a tendency to move towards the centre of the zone. In fact, no particular significance should be attached to the position of the spot exchange rate within the Convertibility Zone.

(ii) The forward exchange rates should normally be inside the Convertibility Zone or stay close to the CUs, unless there are sufficiently large market frictions and transaction costs that prevent arbitrage from taking place.

(iii) A certain level of spread of the Hong Kong-dollar interest rate against the US dollar is consistent with a fully credible Convertibility Zone. The spread does not necessarily move towards zero.

However, between the fourth quarter of 2008 and the end of 2009, the strong-side CU was triggered repeatedly (see Figure 1) and a remarkable HK$640 billion had flowed in for earning higher returns by investing in the equity market of Hong Kong. Furthermore, the forward exchange rates, in particular at the 12-month tenor, persistently fell outside the Convertibility Zone, with the rates stronger than the strong-side CU. In view of these observations, a new analytical framework is needed to explain the dynamics of the Hong Kong-dollar exchange rate. Based on a theoretical model developed in Ma, Tsang, Yiu and Ho (2010), this paper proposes a framework that is consistent with the credibility of the LERS and analyses the exchange-rate dynamics under the current macro-financial conditions.

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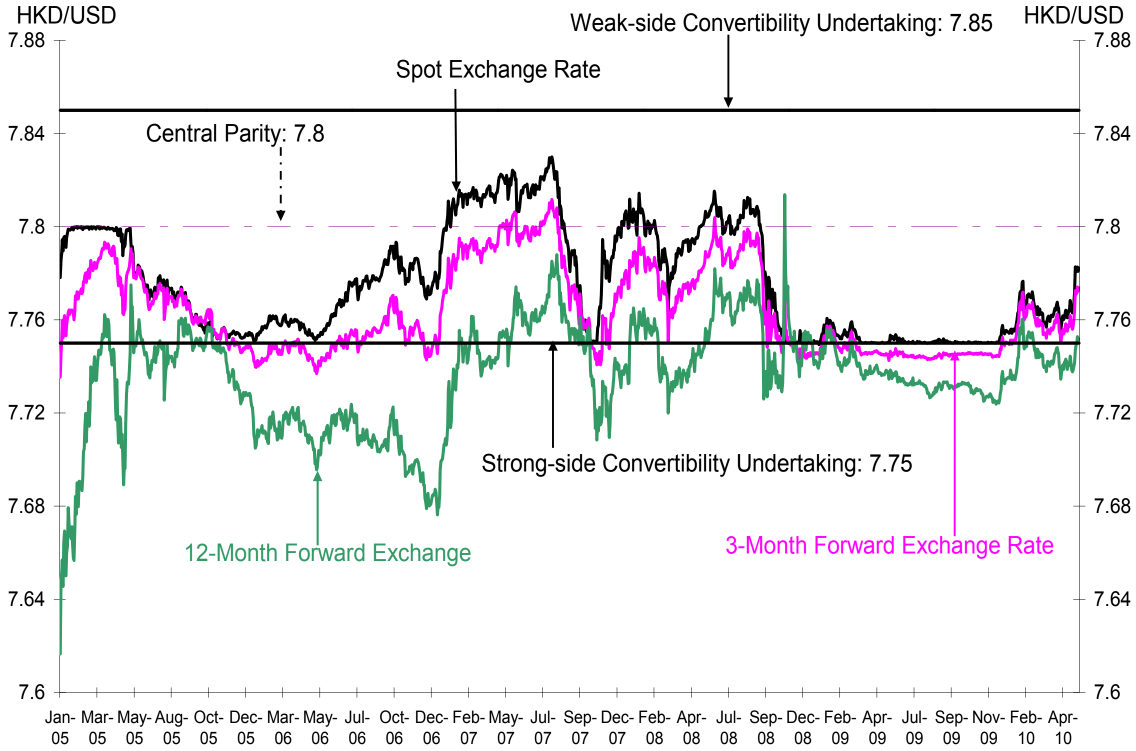
[1] See Genberg, He and Leung (2007), Hui and Fong (2007), Fung and Yu (2007) and Genberg and Hui (2009).

Figure 1: Hong Kong-dollar exchange rate



II. Extended Uncovered Interest Rate Parity

A fully credible exchange-rate target zone regime implies that the forward exchange rates should either be inside the target zone or stay close to the band. If the forward rates are far outside the target zone (which is the Convertibility Zone for the Hong Kong dollar), profits can be made by entering into outright forward contracts, provided that the future spot rate stays within the target zone. If the regime is fully credible, market participants will have incentives to conduct such arbitrage and the forward rates will be brought within the target zone. However, if market participants have doubts about the monetary authorities' ability or willingness to defend the band, then such arbitrage activities might not occur and the forward rates might continue to lie outside the zone. This theoretical argument assumes that the uncovered interest rate parity condition holds such that the expected change in the exchange rate of two currencies depends solely on their interest-rate differential.[2]

[2] This is calculated using the following uncovered interest rate parity condition:

$$\frac{1+i_{t,m}^{HKD}}{1+i_{t,m}^{USD}} = \frac{E[S_t^{t+m}]}{S_t}$$

where $i_{t,m}$ stands for LIBOR or HIBOR with a maturity of m months; E is the expectation of the m-month forward exchange rate; S is the spot exchange rate.

A theory discussed in Genberg, He and Leung (2007) might explain the strong Hong Kong dollar phenomenon and why the 12-month Hong Kong- dollar forward exchange rate was most of the time stronger than the strong-side CU of 7.75. This theory emphasises the importance of opportunity cost: since the local equity market offered very high rates of returns to the major market players, they did not take the trouble to arbitrage away the potential profits arising from the "mis-pricing" of the forward exchange rates. They would be further discouraged from conducting these arbitrage trades if transaction costs and the inherent risks involved in such longer-term trading are taken into consideration. This explanation is consistent with the nature of the substantial fund inflows from late 2008 to 2009, in which the majority of these funds are related to fund-raising activities in the Hong Kong equity market. Because most of the activities involved international placement and thus many overseas investors, large amounts of funds flowed into the Hong Kong dollar.[3]

To incorporate this explanation into a modified target zone model, the framework proposed in this paper is characterised with a portfolio choice over two assets (i.e. one is risk-free and the other is risky such as equity) in two economies (i.e. one is the domestic economy and the other is a foreign economy) made by an investor (for detail derivations, see Ma, Tsang, Yiu and Ho, 2010). The investor chooses an optimal weighting over the four assets that maximises the expected return of the portfolio given the volatility of profits and losses of the portfolio.[4] An equilibrium that we consider is the one characterised by a non-trivial portfolio choice among the four assets in which the investor optimally chooses to hold more than one type of assets in the portfolio. This equilibrium asset allocation implies that the expected change of the exchange rate depends, not only on the risk-free interest rate differential between the Hong Kong dollar and the US dollar (i.e. the uncovered interest rate parity condition), but also the difference between the expected rates of returns on risky assets in Hong Kong and a foreign economy (say the US).

If investors are compensated by a higher expected return from the domestic equity than the foreign (i.e. the US) equity, there could be persistent capital inflows even though the Hong Kong-dollar interest rate is lower than its US dollar counterparty such that the forward exchange rate is stronger than the strong-side CU of 7.75. The strong inflows into the Hong Kong dollar reflect the demands from overseas investors for high rates of returns in the local equity market in particular for the better growth prospect of the listed Mainland companies in Hong Kong.

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[3] See HKMA inSight article on "Latest analysis of fund inflows into the Hong Kong dollar", Norman Chan, 1 February 2010 (http://www.info.gov.hk/hkma/eng/insight/index.htm).

[4] The derivation of the model is available in Appendixes A and B.

As overseas investors are willing to hold non-trivial portions of risk-free monetary assets and equities in their portfolios, the extended uncovered interest rate parity gives the following relationship between the returns on the assets and the exchange rate:[5]

$$\dot{s} = i^{HK} - i^{US} + \alpha(r^{HK} - i^{HK}) - \beta(r^{US} - i^{US})$$

where $\dot{s}$ denotes the change rate of the Hong Kong-dollar exchange rate (expressed as the value in the Hong Kong dollar of one US dollar such that a depreciation of the Hong Kong dollar means a higher s); α and β are the proportions of wealth that the investor invests in the Hong Kong equity and US equity respectively; i and r denote the risk-free interest rate and rate of return on equities respectively (see Ma, Tsang, Yiu and Ho, 2010).

III. ANALYTICAL FRAMEWORK OF MODIFIED TARGET ZONE MODEL

Assuming that the uncovered interest rate parity and the purchasing power parity hold, the conventional target zone model argues that the level of the spot exchange rate within the band is jointly determined by the monetary "fundamental" variables such as relative money supply and demand, and the expected change in the exchange rate.[6] The target zone is assumed to be defended with "marginal" interventions only. Therefore, the monetary authority intervenes in the foreign-exchange market continuously but with a relatively small scale of intervention to keep the exchange rate at the current position before it reaches the band.

Historically, the implementation of target zones in the formation of the European Exchange Rate Mechanism (ERM), apparently based on Krugman's assumption of discretionary interventions by the government with no firm commitments, has not been very successful. There have been frequent realignments of the central parities and changes in the bandwidths of the ERM under speculative attacks (Bertola and Svensson, 1993; Ma and Kanas, 2000).

The current implementation of Hong Kong's LERS is quite different, although it can be analysed as a target-zone model with upper and low bounds. Its early operation from 1983 to 1998 was not based on convertibility guarantee other than reserve requirement on banknote issuance, which supposedly facilitated cash arbitrage. It experienced various tensions, especially during the Asian financial crisis (Tsang and Ma, 2002). However, the post-crisis target-zone arrangements in Hong Kong have been based on explicit convertibility undertakings on the whole monetary base. The enhanced system has proved to be fully robust on the downside since September 1998 as well as on the upside since May 2005 (see Genberg and Hui, 2009).

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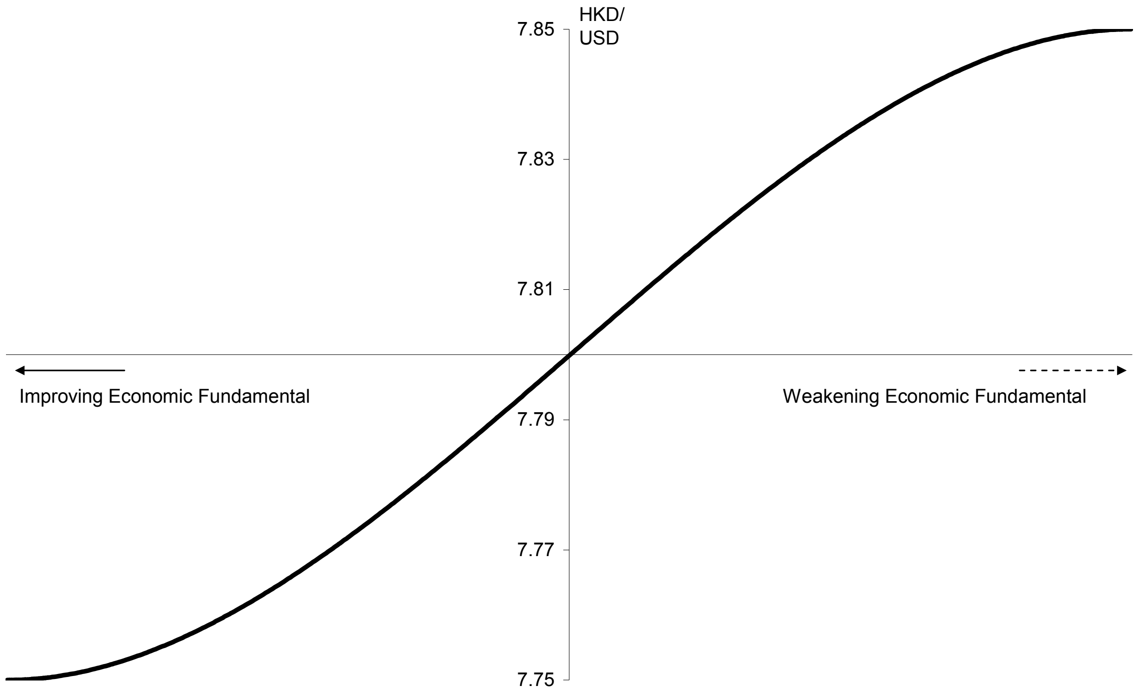
[5] The derivation of this relationship is in Appendix A.

[6] For the detail framework of the conventional target zone model, see Krugman (1991).

The explicit convertibility undertakings in the LERS mean that they will be automatically triggered by market participants, rather than by government interventions, as conceived in Krugman's original 1991 model. Arbitrage activities will ensure the sanctity of the bounds even outside the monetary base (see Tsang, 1996, 1998, 1999; Tsang and Ma, 2002). Rational agents would anticipate the pre-announced policy rule. As a result, full credibility reigns and the spot market rate would never move out of the band.

The conventional target zone model with full credibility predicts an S-shaped relationship between the exchange rate and the monetary fundamental f_m as shown in Figure 2.

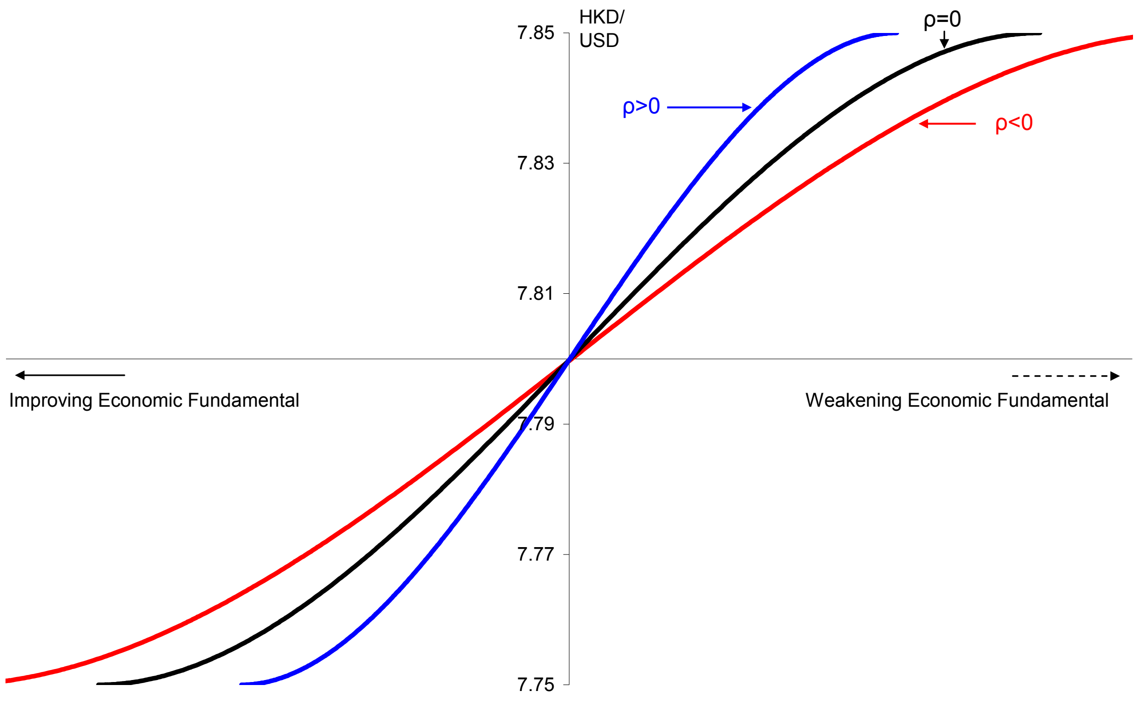
Figure 2: S-shaped relationship between the Hong Kong-dollar exchange rate and monetary fundamental



To study the role of equity returns in driving the Hong Kong-dollar exchange rate dynamics, we modify the conventional target zone according to the role of equity returns discussed in the previous section. The modified target zone model has two types of fundamentals, namely the monetary fundamental f_m and equity fundamental f_e. The equity fundamental is determined by the (relative) dividend growth of the equities in Hong Kong and the US. The modified target zone model still has an S-shaped relationship between the exchange rate and the economic fundamentals, i.e. f_m and f_e, but the characteristics of the relationship are different from those in the conventional model because of the additional equity fundamental.[7]

[7] The deviation of this part of the model is in Appendix B.

Figure 3: Tilted S-shaped relationship under different correlations between monetary and equity fundamentals



When the shock to the return on the Hong Kong equity is positively correlated with the shock to the monetary fundamental, the S-shaped curve that describes the relationship between the exchange rate and the economic fundamentals becomes steeper as shown in Figure 3. As a result, other things being equal, when there is a positive shock to the return on Hong Kong equity, it will attract more market participants to hold the Hong Kong equity, which induces more capital inflows into the Hong Kong dollar (relative to the case of no correlation). Therefore, the Hong Kong-dollar exchange rate will appreciate at an even faster pace.

When the Hong Kong-dollar risk-free interest rate is substantially lower than its US-dollar counterpart (i.e. a negative shock to the monetary fundamental), the spot exchange rate should move along the S-shaped curve within the target zone towards the weak-side CU. However, the negative monetary shock could be somewhat "neutralised" by a positive shock to the equity fundamental. As the rate of return on the Hong Kong equity is higher than that on the US equity such that the positive shock to the equity fundamental is "sufficiently stronger" than the negative shock to the monetary fundamental, the spot exchange rate will be pushed towards the strong-side CU instead. This situation is similar to the strong pace of fund inflows from late 2008 to 2009.

Regarding the dynamics of the forward exchange rate of the Hong Kong dollar, from 2005 to 2009, the 12-month forward exchange rate of the Hong Kong dollar had persistently lied stronger than the strong-side CU. As discussed in Genberg, He and Leung (2007), due to the presence of transaction cost in the foreign exchange market, market participants may not engage in such an arbitrage opportunity. As a result, the actual forward exchange rate can fall outside the Convertibility Zone.

How does our model explain this phenomenon? Since we do not assume any transaction cost in the foreign exchange market in the model derivation, the model-implied forward exchange rate must lie within the convertibility zone under the perfect credibility assumption. Our model argues that investors care about the return on equity in making their portfolio choice decision. If the equity return is high enough, investors do not bother to arbitrage, which may involve non-trivial cost.

Furthermore, the transaction cost involved in longer tenor forward contracts is higher than that involved in shorter tenor contracts. As shown in Figure 1, the three-month forward exchange rate did not go off from the Convertibility Zone as much and often as what the 12-month forward exchange rate did over the same period of time. It may reflect higher costs involved in long-tenor forward contracts than in short-tenor forward contracts. As a result, investors, especially those having long investment horizon in equity market, may have insufficient incentives to arbitrage in long-tenor forward contracts.

This argument is consistent with one possible rationalisation of covered interest parity deviations in terms of the size and extent of credit limits (see Levich, 1985 and Taylor, 1989). According to this rationalisation, a bank determines which other banks it is willing to conduct transactions that entail credit risk, i.e. which banks it is willing to place deposits with and which it is willing to buy and sell foreign exchange with. By assessing the creditworthiness of other banks, the bank determines the maximum size of exposures it is willing to have with each of them at any point in time. This in effect is a constraint on arbitrage operations. Similar to this rationalisation, the complete elimination of pricing differentials between the forward exchange rates and the strong-side CU assumes that market participants, such as banks, have unlimited access to capital. However, credit- and market-risk constraints limit banks' ability to take exposures in long-tenor forward exchange rate contracts with such a sufficient scale. The constraints increase the price of credit and resulted in higher transaction costs, as reflected in wider bid-ask spreads. This would increase the costs of removing the pricing differentials.

IV. SCENARIO ANALYSIS

To analyse the impact of changes in the equity fundamental and monetary fundamental on the exchange-rate dynamics, we use a calibrated version of the modified target zone model to simulate different scenarios of the impact.[8] In the simulation, the equity fundamental is represented by the difference between dividend-adjusted total returns on the Hang Seng Index and S&P 500. The monetary fundamental is represented by the one-month differential between the Hong Kong-dollar HIBOR and US-dollar LIBOR.[9] In each scenario, we assume that the exchange rate starts at 7.8 (the central parity of the LERS) and analyse the impact of a permanent change in the fundamentals on the exchange rate. We thus consider only the long-run impact on the exchange rate under different scenarios.[10]

Benchmark Scenario

We first consider a benchmark scenario where both the expected equity-return differential and interest-rate differential between Hong Kong and the US are kept unchanged (i.e. no shocks to the fundamentals). As shown in Figure 4, there is no change in the exchange rate as expected.

Narrowing Equity-Return Differential

In Scenario b1, the expected equity-return differential between Hong Kong and the US shrinks by 1% (where the return on the Hong Kong equity is higher), while the interest-rate differential is kept unchanged. The projected path of the spot exchange rate in Figure 4 shows that the 1% reduction in the expected equity-return differential induces a weaker Hong Kong dollar of about 300 pips, as marginal investors who seek for higher returns on their portfolios reallocate their assets from Hong Kong equities to other assets under this scenario.

In Scenario b2, the expected equity-return differential between Hong Kong and the US narrows by 1% (as in scenario b1), while the Hong Kong-dollar interest rate increases by one percentage point and the US-dollar interest rate remains unchanged. The increase in the Hong Kong-dollar interest rate implies a tightening of Hong Kong money supply and therefore, counter-balanced the depreciative impact of the narrowing equity-return differential. Figure 4 shows that while the Hong Kong dollar weakens (by approximately 200 pips) due to the shock to the equity fundamental, the change in the exchange rate is less than that in Scenario b1.

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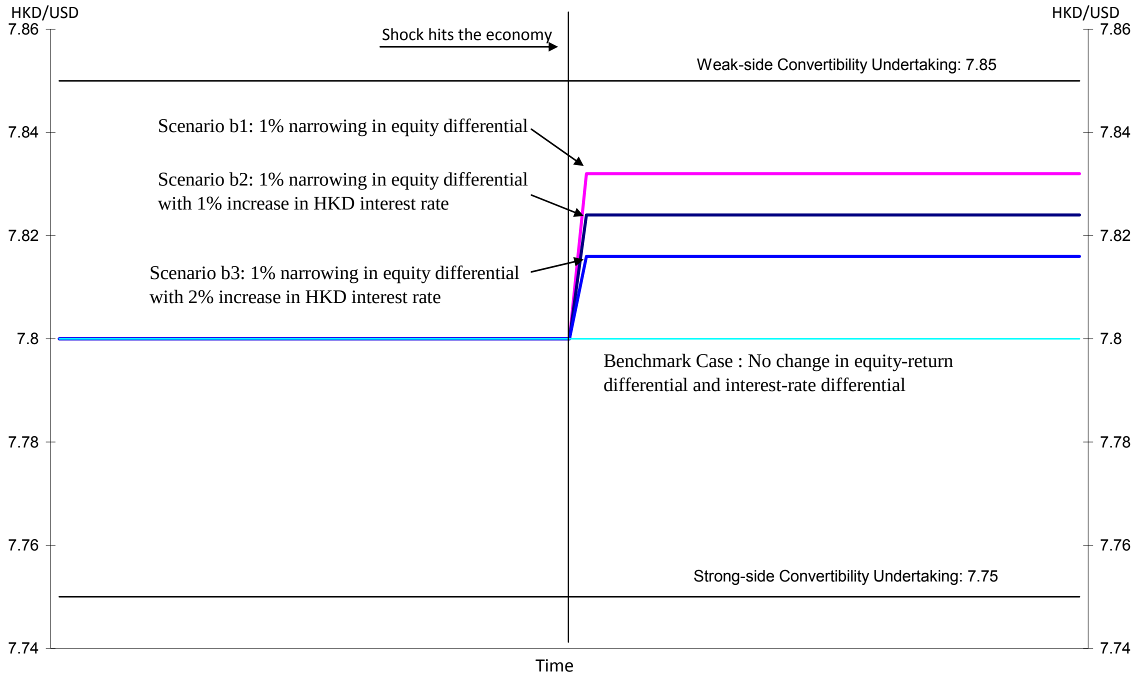
8 It should be noted that the results of the simulation exercise is subject to changes in the calibration of the model. See Appendix C for the description of the calibration procedure.

9 The interbank lending rates are assumed to be risk-free.

10 The analysis of the short-run impact of these scenarios, which requires solving the model with changing expectations, is not discussed here for the sake of simplicity

Figure 4: Scenario analysis of different shocks to fundamentals, 1% narrowing of equity-return differential and one and two percentage-point increases in the Hong Kong-dollar interest rate



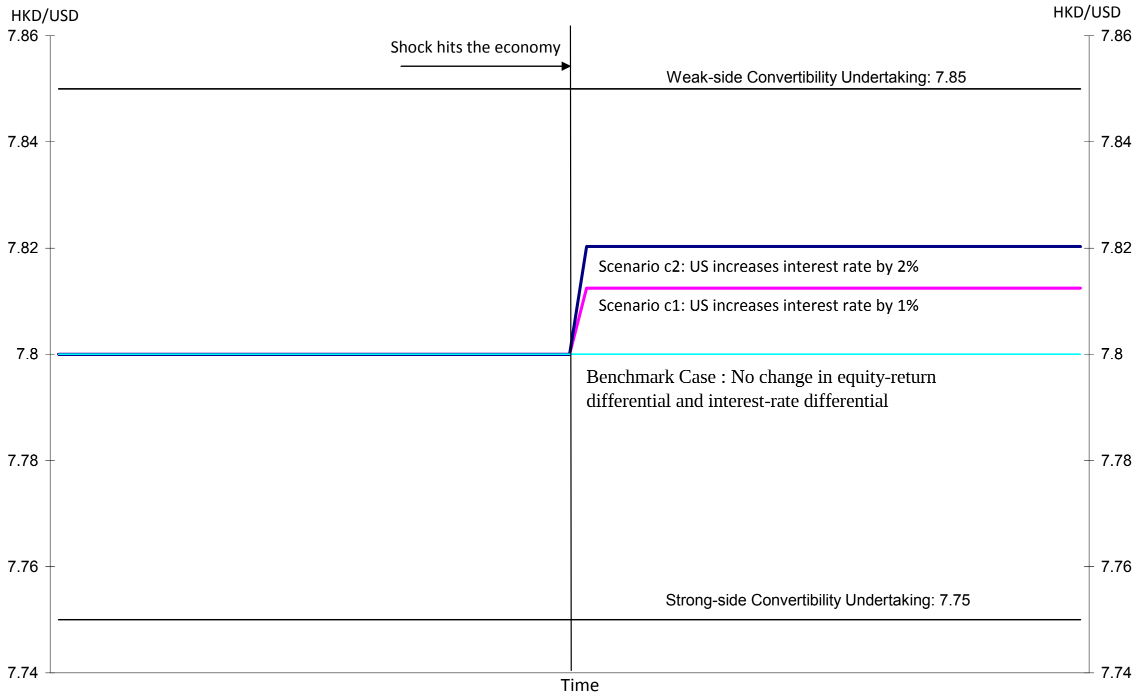
When the Hong Kong-dollar interest rate increases by two percentage points in Scenario b3, the Hong Kong-dollar exchange rate moves closer (weakens by approximately 100 pips) to the central parity as shown in Figure 4. This reflects that the increase in the Hong Kong-dollar interest rate helps limit fund outflows as investors will hold Hong Kong dollars for a higher interest rate.

Increases in the US-Dollar Interest Rate

Figure 5 reports the exchange rate response under two other scenarios. Scenarios c1 and c2 show the cases where the US-dollar interest rate increases "permanently" by one percentage point and two percentage points respectively, while the Hong Kong-dollar interest rate does not follow the changes.[11]

[11] This scenario refers to the situation where the US economy recovers from the financial crisis and its interest rate starts to pick up, while the Hong Kong-dollar interest-rate remains unchanged.

Figure 5: Scenario analysis of different shocks to fundamental, one and two percentage-point increases in the US-dollar interest rate



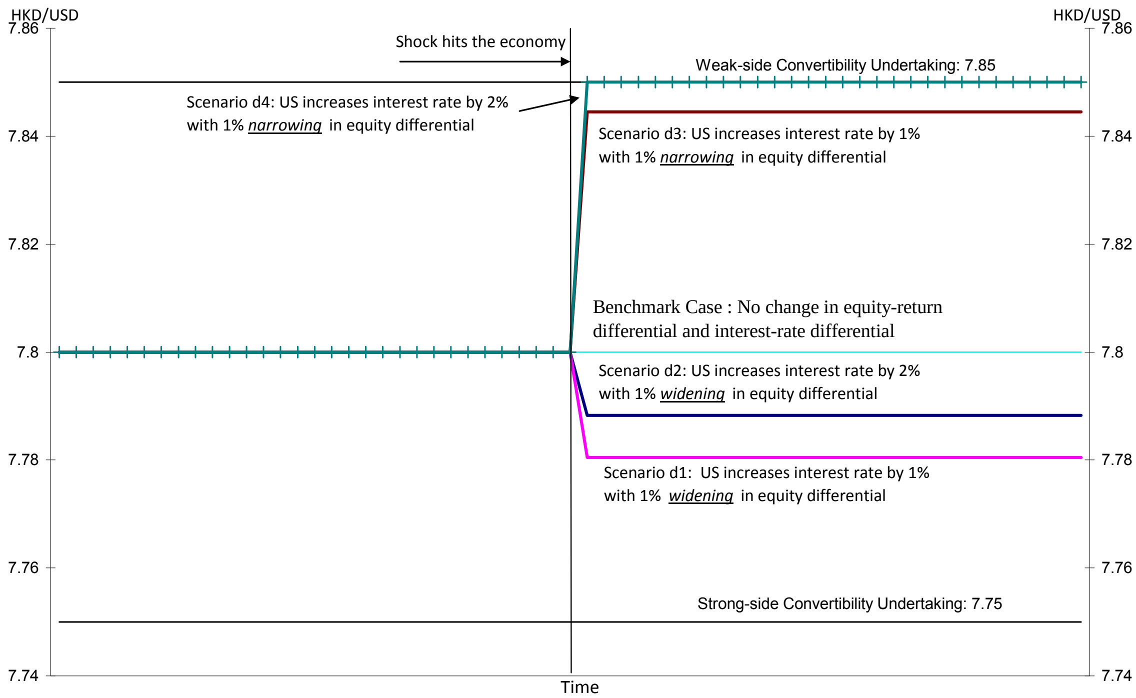
Given that there is no change in the equity-return differential, the increase in the US-dollar interest rate implies that, in the long run, the US dollar appreciates relative to the Hong Kong dollar in these scenarios. Under the current calibration, the Hong Kong-dollar exchange rate will be weakened by 60 pips and 160 pips when the US-dollar interest rate increases by one percentage point and two percentage points respectively.

Finally, we consider four other scenarios. In the first two scenarios, d1 and d2, there is a 1% widening of the equity-return differential (i.e. the return on Hong Kong equity increases by 1% relative to that on the US equity) in response to the one and two percentage-point increases in the US-dollar interest rate, respectively. We then study the impact of “double hits” (in which the US-dollar interest rate increases and the equity-return differential narrows) on the Hong Kong dollar in Scenarios d3 and d4. We assume that in these scenarios, there is a 1% narrowing of the equity-return differential (i.e. the return on Hong Kong equity decreases by 1% relative to that on the US equity) in response to the one and two percentage-point increases in the US-dollar interest rate, respectively. The Hong Kong-dollar interest rate remains unchanged in all these four scenarios.

Figure 6 shows the simulation results of the four scenarios. Regarding Scenarios d1 and d2, we find that the impact of the 1% widening of the equity-return differential overcomes the depreciative impacts of the one and two percentage-point increases in the US-dollar interest rate and, in net, pushes the Hong Kong dollar to appreciate by about 150 pips and 50 pips respectively. Under these two scenarios, while the increases in the US interest rate induce capital outflows from Hong Kong and cause the Hong Kong dollar to depreciate, the increase in Hong Kong equity return offsets the impact by offering a higher equity return to investors and, therefore, limits the outflow of capitals.

On the other hand, in Scenarios d3 and d4, we find that the impact of the 1% narrowing of the equity-return differential amplifies the depreciative impact of the one and two percentage-point increases in the US-dollar interest rate and pushes the Hong Kong dollar towards the weak-side CU. Quantitatively, the Hong Kong dollar depreciates by about 470 pips and 540 pips respectively and, in particular, the Hong Kong dollar hits the weak-side CU in Scenario d4. It is not surprising to see that, under these “double hits” scenarios, the Hong Kong dollar depreciates by a significant amount. However, since Hong Kong-dollar movements are limited by the target zone band, they will not go beyond the weak-side CU, like Scenario d4.

Figure 6: Scenario analysis of different shocks to fundamentals, one and two percentage-point increases in the US-dollar interest rate with a 1% widening and a 1% narrowing of equity-return differential



V. CONCLUSION

Between the fourth quarter of 2008 and the end of 2009, the strong-side CU was triggered repeatedly with remarkable capital inflows into the Hong Kong dollar. Furthermore, the forward exchange rates in particular at the 12-month tenor persistently fell outside the Convertibility Zone, with the rates stronger than the strong-side CU. Based on the theoretical framework of Ma, Tsang, Yiu and Ho (2010), this paper investigates empirically a modified target zone model for the Hong Kong dollar, which allows us to explain the possible causes of these market movements.

The modified model allows non-trivial portfolio choices between risk-free monetary assets and risky equities. In the model, the Hong Kong-dollar exchange rate movements depend on both the changes in the expected equity-return differential between Hong Kong and the US (i.e. the equity fundamental) and in the monetary fundamental. The typical S-shaped relationship between the exchange rate and the economic fundamentals in a target zone model becomes steeper taking into consideration the equity fundamental. In other words, the exchange-rate dynamics are more sensitive to the underlying movements of the fundamentals than implied by the conventional target zone models.

The simulation results using the modified model show that, for example, a 1% narrowing between the expected returns on equities in Hong Kong and the US weakens the Hong Kong dollar by about 300 pips. An increase in the Hong Kong-dollar interest rate can act as a counter-factor but it requires a significant increase in order to overcome the effect from the equity return. On the other hand, a one percentage-point increase in the US-dollar interest rate with no change in the Hong Kong-dollar interest rate will weaken the Hong Kong dollar by about 60 pips. If the return on Hong Kong equity increases by 1% at the same time, it can however act as a counter-factor, limiting the scale of capital outflows and causing the Hong Kong dollar to appreciate by about 150 pips. Finally we look at the combination of adverse shocks that would push the spot exchange rate towards the weak-side CU. In this case, a one percentage-point increase in the US-dollar interest rate together with a 1% narrowing of equity-return differential will weaken the Hong Kong dollar by about 470 pips.

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Appendix A: Derivation of Extended Uncovered Interest Rate Parity

This Appendix is based on the theoretical model developed by Ma, Tsang, Yiu and Ho (2010). We extend the set-up of Mark and Wu (1998) to assume that investors with initial wealth W_t would hold domestic (Hong Kong interchangeably) and foreign (US interchangeably) portfolios with two assets of (risk-free) bonds and (risky) equities. Investors take the interest rate of bond, expected return on equities of the two economies and the exchange rate as given and invest a fraction δ of their total wealth in the domestic portfolio and the remaining $1-\delta$ in the foreign portfolio. The spot exchange rate S_t is defined conventionally as Hong Kong dollars per one US dollar. A fraction $(1-\alpha)$ of the total value of the domestic portfolio is invested in domestic bonds and earns net interest rate i_t^{HK}, and the remaining α fraction is invested in domestic equities, with future payoff $\alpha\,(1+r_{t+1}^{HK})$. Similarly, investors hold a fraction $(1-\beta)$ of their foreign portfolio uncovered (from exchange-rate fluctuations) in foreign bonds and a β fraction of foreign equities with the next period payoff $(1-\beta)\,(1+i_t^{US})\,S_{t+1}/S_t$ and $\beta\,(1+r_{t+1}^{US})\,S_{t+1}/S_t$ in the home currency respectively. Therefore, the next period nominal wealth of the representative investor evolves as follows:

$$\begin{aligned} W_{t+1} = \{&\delta\,[(1-\alpha)\,(1+i_t^{HK}) + \alpha\,(1+r_{t+1}^{HK})] \\ &+ (1-\delta)\,[(1-\beta)\,(1+i_t^{US}) + \beta\,(1+r_{t+1}^{US})]\,S_{t+1}/S_t\}\,W_t \end{aligned} . \tag{A.1}$$

We assume that investors are mean-variance optimisers with a risk-adjusted return defined as follows:

$$\max \mathrm{J} = \mathrm{E}_t\,(W_{t+1}) - \frac{1}{2}\theta\,\mathrm{Var}\,(W_{t+1}),$$

where θ is the degree of risk-aversion of agents. By assuming $\theta \cong 0$, i.e., investors are risk-averse still but the degree of risk-aversion is rather small (for analytic tractability of the model), we obtain the following expression:

$$S_{t+1}/S_t = [1+(1-\alpha)\,i_t^{HK} + \alpha\,r_{t+1}^{HK}]\,/\,[1+(1-\beta)\,i_t^{US} + \beta\,r_{t+1}^{US}]\,. \tag{A.2}$$

By changing both sides in a log-scale, we have:

$$\begin{aligned} \dot{s}_{t+1} &\cong (1-\alpha)\,i_t^{HK} + \alpha\,r_{t+1}^{HK} - (1-\beta)\,i_t^{US} - \beta\,r_{t+1}^{US} \\ &= i_t^{HK} - i_t^{US} + \alpha\,(r_{t+1}^{HK} - i_t^{HK}) - \beta\,(r_{t+1}^{US} - i_t^{US}) \end{aligned} . \tag{A.3}$$

The above is the extended uncovered interest rate parity for two types of assets.

Appendix B: Derivation of Modified Target Zone Model

This Appendix provides the main results of the modified target zone model. For detail derivations, see Ma, Tsang, Yiu and Ho (2010).

Continued from Appendix A, the extended uncovered interest parity is as follows:

$$\dot{s}_{t+1} = i_t^{HK} - i_t^{US} + \alpha(r_{t+1}^{HK} - i_t^{HK}) - \beta(r_{t+1}^{US} - i_t^{US}) \tag{B.1}$$

To derive the modified target zone model, we assume that the money demand function for Hong Kong and the US are given by:

$$m_t^{US} - p_t^{US} = \phi^{US} y_t^{US} - a^{US} i_t^{US},$$

$$m_t^{HK} - p_t^{HK} = \phi^{HK} y_t^{HK} - a^{HK} i_t^{HK},$$

and the relationship among p_t^{US}, p_t^{HK} and s (all in log) is given by the following generalised purchasing power parity:

$$p_t^{HK} = c_1 p_t^{US} + c_2 s_t \quad .$$

where c_1 and c_2 are positive constants, which implies Hong Kong will experience inflation when US experiences inflation and/or when the Hong Kong dollar depreciates.

Following Ma, Tsang, Yiu and Ho (2010), we define the monetary fundamental as follows:

$$\begin{aligned} f_m(t) \equiv\ & c_3\left(\phi^{HK} y_t^{HK} - m_t^{HK} + c_1\ p_t^{US}\right) \\ & - \frac{a^{HK}}{1-\alpha} \frac{(1-\beta)c_3}{a^{US}} \left(\phi^{US} y_t^{US} - m_t^{US} + p_t^{US}\right) \end{aligned} \tag{B.2}$$

Based on the Gordon dividend growth model, we have the following expressions:

$$r_t^{HK} = \log(P_{t+1}^{HK}) - \log(P_t^{HK}) = \log(D_{t+1}^{HK}) - \log(D_t^{HK}) \equiv \dot{d}_t^{HK},$$

$$r_t^{US} = \log(P_{t+1}^{US}) - \log(P_t^{US}) = \log(D_{t+1}^{US}) - \log(D_t^{US}) \equiv \dot{d}_t^{US}.$$

Since dividend is considered as the fundamental of equity and the Gordon model shows that the rate of return on equity is the dividend growth, we define the equity market fundamental as:

$$f_e(t) \equiv \frac{a^{HK}}{1-\alpha} c_3 \left(\alpha\, r_{t+1}^{HK} - \beta\, r_{t+1}^{US}\right) . \tag{B.3}$$

Ma, Tsang, Yiu and Ho (2010) then derive the following target zone model with two assets as follows:

$$\mu E_t(\dot{s}_t) = s_t + f_m + f_e , \tag{B.4}$$

where $\mu \equiv \frac{a^{HK}}{1-\alpha} c_3$. (B.5)

If we further define the composite economic fundamental as:

$$f_c(t) \equiv f_m(t) + f_e(t) , \tag{B.6}$$

we arrive at the same form of the conventional target zone model.

Assuming that the composite economic fundamental follows the following process:[12]

$$df_c(t) = \eta_c dt + \sigma_c dz_c(t) , \tag{B.7}$$

then the solution to the exchange rate process is the following expression:

$$s_t = \eta_c \mu + f_c(t) + A\exp(\lambda_1 f_c(t)) + B\exp(\lambda_2 f_c(t)), \tag{B.8}$$

where

$$\begin{aligned} \lambda_1 &= -\frac{\eta_c}{\sigma_c^2} + \sqrt{\frac{\eta_c^2}{\sigma_c^4} + \frac{2}{\mu\sigma_c^2}} \\ \lambda_1 &= -\frac{\eta_c}{\sigma_c^2} - \sqrt{\frac{\eta_c^2}{\sigma_c^4} + \frac{2}{\mu\sigma_c^2}} \end{aligned} ,$$

and

$$\begin{aligned} A &= \frac{\exp(\lambda_2 \overline{f}_c) - \exp(\lambda_2 \underline{f}_c)}{\lambda_1 \left[\exp(\lambda_1 \overline{f}_c + \lambda_2 \underline{f}_c) - \exp(\lambda_1 \underline{f}_c + \lambda_2 \overline{f}_c)\right]} \\ B &= \frac{\exp(\lambda_1 \underline{f}_c) - \exp(\lambda_1 \overline{f}_c)}{\lambda_2 \left[\exp(\lambda_1 \overline{f}_c + \lambda_2 \underline{f}_c) - \exp(\lambda_1 \underline{f}_c + \lambda_2 \overline{f}_c)\right]} \end{aligned} .$$

[12] We assume the monetary fundamental and equity fundamental follow a random walk with a drift.

Finally the governing parameters of the composite economic fundamental are given by:

$$\eta_c = \eta_m + \eta_e$$
$$\sigma_c^2 = \sigma_m^2 + \sigma_e^2 + 2\rho_{m,e}\sigma_m\sigma_e \quad ,$$

where η_m and η_e are the drifts of the monetary fundamental and equity fundamental processes respectively, and σ_m and σ_e are the standard deviations of the shocks to the monetary fundamental and equity fundamental respectively, and ρ is the correlation between shocks to the two fundamentals.

This completes the main structure of the modified target zone model. We show that the structural parameters of the modified target zone model are functions of not only the parameters that govern the monetary fundamental but also the parameters that govern the equity fundamental. As a result, our model generates a steeper (flatter) S-shaped curve than the conventional target zone model with only one asset when the two types of fundamental are positively (negatively) correlated. For more details, see Ma, Tsang, Yiu and Ho (2010).

Appendix C: Calibration and Simulation of the Modified Target Zone Model

The model is calibrated to the following parameter values for the simulation exercises in the main text:

Parameter	Calibrated Value
μ	**0.77**
η_c	**2.55**
σ	**0.75**
$\underline{f}$	**6.11**
$\overline{f}$	**8.60**

The calibrated parameter values are obtained by using Simulated Method of Moments (SMM) and mostly in line with the literature (see De Jong (1994) and Mark (2002)). In particular, the calibrated values in the case of Hong Kong are close to those in the case of the Irish punt, as reported in De Jong (1994).

Our calibration procedure allows us to extract a series of composite fundamentals (which are generated by Equation B.8) that supports the calibrated parameter values. The extracted composite fundamental on the risk-free interest rate differential between the Hong Kong dollar and US dollar and the equity-return differential is as follows:

$$f_c = \beta_1\left(i^{HK} - i^{US}\right) + \beta_2\left(r^{HK} - r^{US}\right) \tag{C.1}$$

Finally, the simulation exercises reported are generated in the following way. Given the parameter estimates in Equation C.1, we calculate the counter-factual composite fundamental and then calculate the corresponding implied exchange rate by Equation B.9. Since there are multiple sets of extracted composite fundamentals that support the calibrated parameter values, the parameter estimates in equation C.1 are subjects to changes in the extracted composite fundamental. The simulation results reported in the text are based on the set of extracted composite fundamentals that yields the highest R-squared (which is about 0.15) in the regression of equation C.1. The corresponding parameter estimates of Equation C.11 is $\beta_1 = 2.12$ and $\beta_2 = 6.85$.