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Joseph K. W. Fung, Robert I. Webb and Wing H. Chan

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Do Derivative Markets Contain Useful Information for Signaling "Hot Money" Flows?

Joseph K. W. Fung
Hong Kong Institute for Monetary Research
Hong Kong Baptist University

and

Robert I. Webb
Hong Kong Institute for Monetary Research
University of Virginia

and

Wing H. Chan
City University of Hong Kong
Wilfrid Laurier University

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Abstract

This study examines whether information from derivative markets is useful for signaling "hot money" and other large capital flows in an economy where the monetary authority pursues a policy of exchange rate stability. Specifically, this study examines the information content of various Hong Kong traded derivative securities for signaling changes in the *aggregate balance* of the Hong Kong banking system during a period of intense IPO activity and speculation on the revaluation of the renminbi. The impact of the introduction of the Hong Kong Monetary Authority's (HKMA) *Convertibility Undertakings* on the dynamic relationships among capital flows, stock market volatility and stock market turnover is also examined. Finally, the implications for monetary policymakers in potentially using information from derivative markets are assessed.

The results show that derivative markets contain useful information for signaling "hot money" flows. Granger causality tests from a VAR model show that Hong Kong dollar forward and RMB non-deliverable forward (NDF) prices predict future variation in the aggregate balance. Moreover,

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changes in aggregate balance has a significant impact on Hong Kong's interbank rates. The findings also suggest that the introduction of the May 18, 2005 Convertibility Undertakings may have increased the credibility of the Linked Exchange Rate System by discouraging the use of the Hong Kong dollar and Hong Kong dollar denominated assets as speculative vehicles on RMB denominated assets.

1. Introduction

It is widely recognized that "*hot money*" and other large movements of capital, both into and out of a country, can exert a significant impact on financial markets and the overall economy. Large capital inflows: exert upward pressure on the exchange rate by raising the demand for the local currency; decrease interest rates by increasing the supply of credit; and increase asset market turnover and bid up the prices of both investment and consumption goods. Conversely, large capital outflows: exert downward pressure on the local currency's exchange rate and asset prices; promote greater short-run market turnover; and lead to higher interest rates as the supply of credit decreases. The volatility of asset prices may also be affected by capital flows.

The impact of hot money on financial markets is especially easy to see when a monetary authority pursues a stable exchange rate policy via a currency board because the exchange rate is not allowed to adjust much. If the mechanical nature of a currency board system leads to predictable effects on interest rates and asset prices following a large capital flow, the question that naturally arises is whether derivative markets are able to anticipate some of the likely financial market response?

The experience of Hong Kong is especially interesting because: its de facto central bank, the Hong Kong Monetary Authority (HKMA), employs a currency board system ("Linked Exchange Rate System"); the territory has active derivative markets; and "hot money" may arrive due to a change in the perceived fundamentals of Hong Kong and the Chinese Mainland, or as a "play" on the Chinese renminbi (RMB).

This study attempts to ascertain whether information from Hong Kong's derivative markets is useful for signaling "hot money" and other large capital flows during a commonly agreed period of intense IPO activity and speculation on a revaluation of the renminbi.[1] The choice of time period is deliberate. If derivative markets contain useful information in signaling hot money flows, the information should be readily apparent during a period of intense speculation. Several possible sources of information from derivative markets are examined. These include: changes in Hong Kong Inter-Bank Offer Rate (HIBOR) futures prices, changes in Hong Kong dollar forward prices; changes in non-deliverable forward prices on the renminbi; and changes in the implied volatility of Hang Seng stock index futures options. This approach allows one to determine if some derivative markets contain more information than others or signal earlier than others.

[1] Some observers attribute the use of the Hong Kong dollar as a vehicle to speculate on the renminbi to the communiqué from the G-7 Finance Ministers conference in Dubai on September 20, 2003. The communiqué stated: "We reaffirm that exchange rates should reflect economic fundamentals. We continue to monitor exchange markets closely and cooperate as appropriate. In this context, we emphasize that more flexibility in exchange rates is desirable for major countries or economic areas to promote smooth and widespread adjustments in the international financial system, based on market mechanisms." Many market participants believed that the acquisition of HKD denominated assets was a way to play the expected appreciation of the RMB against the U.S. dollar. The Hong Kong dollar strengthened sharply after the conference and hit 7.711 to the U.S. dollar on October 7, 2003.

1.1 The Hong Kong Monetary Authority and the Currency Board System

The Hong Kong government implemented the current currency board system—the Linked Exchange Rate System—in 1983. The system commits the Hong Kong Monetary Authority to maintain the exchange rate of the Hong Kong dollar to the United States dollar within narrow bounds.[2] The HKMA stands ready to buy and sell U.S. dollars (USD) and to absorb any impact that capital flows may have on the linked exchange rate.[3] When a local bank receives a U.S. dollar deposit and (the client) wants to convert it into Hong Kong dollars (HKD), the HKMA will buy the US dollars at the linked rate and credit the clearing account of the bank with an equivalent amount of Hong Kong dollars.[4] This increases the clearing balance of the bank and the *aggregate balance* of the banking system—the sum of all bank clearing balances on deposit at the HKMA. The purchase of Hong Kong dollars puts upward pressure on the exchange rate while the resultant expansion of the monetary base puts downward pressure on interest rates. Similarly, if the client withdraws the US dollar denominated deposit, the bank sells Hong Kong dollars to the HKMA at the linked rate and the HKMA debits the clearing account of the bank and credits the bank with an equivalent amount of US dollars. This reduces the clearing balance of the bank and also the aggregate balance.[5] The sale of Hong Kong dollars puts downward pressure on the exchange rate and, with the contraction of the monetary base, upward pressure on interest rates. Hence, the aggregate balance increases with capital inflows and decreases with capital outflows and can impact exchange and interest rates. Under the Convertibility Undertakings, there is no limit on the maximum size of the aggregate balance.[6]

We use daily changes in the aggregate balance as a proxy for "hot money" flows. The behavior of the daily closing value of the aggregate balance surrounding the introduction of the Convertibility Undertakings is depicted in Figure 1. As is readily apparent, the aggregate balance rose sharply in the last quarter of 2003 and peaked during the first half of 2004. The aggregate balance remained largely constant for a few months and then fell sharply during the second half of 2004 to a level about the same as during the last quarter of 2003 before rising sharply during the end of 2004 and the beginning of 2005. The aggregate balance rose sharply in early 2005 but peaked at a far lower level in early 2005 than it did in 2004. The aggregate balance fell sharply during the first quarter of 2005 such that it was at about the same level as it was during October 2003 before the Convertibility Undertakings of May 18, 2005. The

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2 This commitment is known as the *Convertibility Undertakings*. The range in which the Hong Kong dollar exchange rate may fluctuate is known as the *convertibility zone*.

3 Under the currency board system, the entire monetary base in Hong Kong has to be at least 100% backed by USD denominated assets.

4 All licensed banks in Hong Kong have a clearing account with the HKMA. The balance that each bank has in the account is for inter-bank settlement purposes. The balance in the account does not yield any interest. The aggregate balance is also a measure of the overall level of interbank liquidity.

5 Licensed Hong Kong banks can also borrow funds intraday from the HKMA via the liquidity adjustment window or overnight via the discount window. In both cases, the bank must pledge collateral as security.

6 The aggregate balance reached HK$52 billion in January of 2004 according to Yam (2004).

aggregate balance fell after the Convertibility Undertakings and, with some minor exceptions, remained relatively low through December 2006.

Figure 2 depicts the natural logarithm of the closing value of the aggregate balance during the same period as Figure 1 (i.e., September 3, 2002 through December 29, 2006). The key point is that the aggregate balance was fairly flat before the fourth quarter of 2003 and after the Convertibility Undertakings of May 18, 2005.

As noted above, the aggregate balance is a good measure of capital flows in and out of Hong Kong's banking system as well as a measure of the aggregate liquidity in the banking system. The aggregate balance also constitutes (a usually small) part of Hong Kong's monetary base.[7] Because of the highly efficient inter-bank settlement system—the Real Time Gross Settlement System (RTGS), under normal circumstances, the total aggregate balance has frequently been kept below HKD 1 billion (Yam, 2004).[8]

The individual clearing balances on deposit at the HKMA do not earn interest. As a result, when there is an increase in the aggregate balance, there is an economic incentive for banks to reduce their individual excess clearing balances by lending them in the interbank market—the Hong Kong equivalent of the Fed Funds market in the US. This lowers the interbank interest rate. Similarly, interbank rates are driven up when liquidity is withdrawn from the banking system following an exit of capital. Hence, capital flows impact local interest rates through their effect on the aggregate balance of the banking system and the attempts by banks to minimize their opportunity cost of maintaining excessive clearing balances.

1.2 Causes of Large Capital Flows or Changes in Interbank Liquidity

Large capital flows may arise for a number of reasons. First, foreign investors may want to quickly change their asset allocation in Hong Kong based assets. Second, interest by foreign investors in both initial public offerings (IPOs) and seasoned issues by large Mainland Chinese companies may induce a surge in capital flows into Hong Kong. For instance, the IPO of H-shares by the Bank of China (Hong Kong) in June 2006 was over-subscribed by about 76 times and HK$286 billion (USD 36.7 billion) was temporarily invested in the subscription process in Hong Kong. This example also illustrates that "hot money" and IPO effects may sometimes be intertwined. Third, capital inflows into Hong Kong may reflect foreign attempts

[7] The monetary base includes Certificates of Indebtedness issued by the HKMA to the three note-issuing banks in Hong Kong (for backing their note issues), coins and $10 dollar notes issued by the HKMA, Exchange Fund Bills and Notes issued by the HKMA, and the aggregate balance.

[8] For a prolonged period between December 2004 and early 2005, the aggregate balance had been hovering around HK$15.8 billion (Yam, 2005a). During the period, the Hong Kong dollar was consistently on the strong side of the link and HKD interest rates were below comparable USD interest rates. On 18 May 2005, HKMA implemented the Convertibility Undertakings and committed the HKMA to sell (buy) HKD at 7.75 (7.85) so that the currency does not strengthen (weaken) beyond that point. Yam (2005b) indicated that "hot money" left the Hong Kong banking system following the introduction of the two-way Convertibility Undertakings and the local interest rates realigned with the USD rates.

to speculate on potential appreciation of the RMB.[9] Fourth, large capital flows may be related to speculation on whether the HKMA will maintain the HKD/USD peg or on the direction of the Hong Kong stock market.

The adverse effects of sudden large capital flows can best be illustrated with the experiences of Hong Kong during the Asian financial crisis. Speculators made several attempts to break the fixed rate link of the Hong Kong dollar to the US dollar following the advent of the Asian Financial Crisis in 1997. Although these speculative attacks failed they resulted in large increases in local interest rates—at one point in late October 1997, short term interest rates in Hong Kong approached 300%—and induced sharp declines in Hong Kong equity prices which spilled over to U.S. equity markets on Monday, October 27, 1997.[10] Nevertheless, the Linked Exchange Rate System worked. The Hong Kong dollar/US dollar link was maintained and the speculators who had bet on breaking the link suffered significant losses.[11]

However, this episode did not fully deter subsequent speculation against the HKD/USD exchange rate link it merely changed its form. One lesson some speculators learned from the failed speculative attacks on the HKD/USD linked exchange rate in 1997 was that the attacks induced sharp declines in equity prices. This meant that it might be possible to profit from subsequent speculative attacks on the HKD/USD linked rate even if the exchange rate held by shorting the equity and equity derivative markets in advance of any attack on the exchange rate. Such an attack occurred in 1998, when some speculators borrowed about HK$30 billion in the currency swap market and then shorted Hang Seng stock index futures acquiring a position of approximately 80,000 futures contracts in the process. The speculators then waited for an appropriate moment to short the Hong Kong dollar in order to induce a sharp rise in short-term interest rates and a sharp decline in stock prices. The HKMA recognized the threat and intervened in the stock and stock index futures market in order to foil the attempted manipulation of the Hong Kong equity market by speculators.[12]

If a potential foreign investor takes a substantial position in Hong Kong asset markets, the investor has to ensure that he has sufficient Hong Kong dollars to settle the trade. This may entail taking an equally sizable position in the local currency to conclude the transaction. (Hong Kong has a T+2 days settlement rule for stock transactions.) The relevant point is that the foreign investor has to prepare for the transaction before it actually concludes. The act of preparation means that there may be a leakage of the information from the investor before the transaction is concluded. Economic theory suggests that this

9 See for example, Yam (2005b), Lee and Poon (2005), SFC (2006), Bank of China (2004, 2007).

10 Yam (1998b).

11 Webb, (2007).

12 A fuller account of this episode can be found in a speech entitled “Coping with Financial Turmoil” delivered by Joseph Yam on 23 November 1998 (Yam, 1998b).

information may be partially revealed through activity in related markets. Derivative markets are likely to reflect such information because transaction costs are often lower.

For instance, if the investor anticipates taking a sizable long position in the stock market within a certain time frame, he may take a long position in the equity index call option or equity index futures markets to lock in a price. These transactions in the options and futures markets may significantly affect the price, volume, and open interest of these derivatives and convey information to other market participants. Such derivative market transactions may convey information about prospective capital flows to the Monetary Authority.

Given that an increase in the aggregate balance reduces the interbank interest rate and a decrease in the aggregate balance increases the interbank interest rate, the informed trader may have an incentive to act on information that would significantly impact the aggregate balance by taking an appropriate position in the interest rate futures market. Simply put, the volume and open interest of the HIBOR futures contract should go up.[13]

Of course, information may flow in both directions. For instance, an increase in the aggregate balance may be indicative of an increase in demand for Hong Kong dollars. As a result, the HKD forward discount may widen as forward prices fall in anticipation of a large rise in the aggregate balance, and vice versa.

Finally, it should be noted that not all bets on the Hong Kong dollar or the Hong Kong equity market need entail the actual conversion of foreign currency into or out of Hong Kong dollars. Market participants may enter into forward market positions or currency swap positions without initially converting funds into Hong Kong dollars. Similarly, market participants may place bets on the Hong Kong dollar by acquiring futures or option market positions. Such position may entail potentially converting only a small amount of the aggregate bet to cover cash outflows associated with adverse price moves in the case of futures contracts or the cost of acquiring the option. These alternative avenues of speculation mean that changes in the aggregate balance may tell only part of the story. Simply put, derivative markets provide market participants with a means of circumventing restrictions on capital flows as well as potential sources of information about future capital flows.

1.3 Introduction of the Convertibility Undertakings

The Linked Exchange Rate System links the Hong Kong dollar to the United States dollar at a fixed rate of 7.80. However, the Hong Kong dollar may strengthen or weaken against the United States dollar as demand for the Hong Kong dollar increases or decreases. Prior to May 18, 2005, the amount by which

[13] The anticipated direction of the money flow may also be reflected in the change in interest rate futures prices. This subject is beyond the scope of this paper and the current study focuses on index options prices.

the Hong Kong dollar would be allowed to appreciate against the U.S. dollar was unknown.[14] Anticipated gains from a favourable move in the exchange rate beyond 7.80 led many foreign investors to "hoard" Hong Kong dollars. The massive capital inflows into the Hong Kong dollar from foreign investors resulted in a near-zero interest rate.

On May 18, 2005, the Hong Kong Monetary Authority announced some changes to the operation of the Linked Exchange Rate System. These changes are commonly known as the *Convertibility Undertakings* and were "aimed at removing uncertainty about the extent to which the exchange rate may strengthen under the Linked Exchange Rate System."[15] Essentially, the HKMA established an explicit range over which it would intervene to maintain the linked exchange rate. Specifically, it established a lower bound rate for appreciation—strong-side convertibility—at 7.75 and a similar upper bound rate for depreciation—weak-side convertibility—at 7.85. The HKMA committed itself to potential interventions in the currency market to buy (sell) US (Hong Kong) dollars on the strong-side and sell (buy) US (Hong Kong) dollars on the weak-side to maintain the Linked Exchange Rate System.

Prior to the undertaking, overseas investors were hoarding Hong Kong dollars despite the fact that HIBOR was close to zero. The large Hong Kong dollar reserve in the banking system was a tool for direct speculation on further Hong Kong dollar appreciation and an indirect bet on RMB appreciation. Introduction of the Convertibility Undertakings reduced the incentives of market participants to maintain large reserves of Hong Kong dollars. In addition to reducing uncertainty about how much the Hong Kong dollar would be allowed to appreciate against the US dollar, the policy action was intended to "reduce the usage of the Hong Kong dollar as a vehicle for speculation on a revaluation of the renminbi" according to Mr. Joseph Yam, Chief Executive of the HKMA.[16]

The aggregate balance fell following the adoption of the refinements to the Linked Exchange Rate system. The undertaking appears to have reduced speculation on further appreciation of the Hong Kong dollar as intended. It also appears to have reduced speculation on the RMB via the Hong Kong dollar.[17] Indeed, one could argue that the Hong Kong dollar would have been under greater speculative pressure prior to the revaluation of the renminbi on July 21, 2005 had the HKMA not introduced the Convertibility

[14] This policy was known as *constructive ambiguity* and was in place during a period when the Hong Kong dollar experienced weakness.

[15] HKMA, "Refinements to the Operation of the Linked Exchange Rate System," press release, May 18, 2005.

[16] Ibid.

[17] The Peoples Bank of China revalued the RMB from 8.28 to 8.11 per US dollar on July 21, 2005. The change was effective as of 7:00 p.m. on July 21st.

Undertakings on May 18, 2005.[18]

1.4 Outline

This study uses daily data covering the period January 2, 2004 to December 29, 2006 to determine whether changes in the aggregate balance impact various financial variables and whether changes in derivative prices and implied volatility reveal information on impending large capital flows into and out of Hong Kong during a period of intense IPO activity and speculation on a revaluation of the RMB. Specifically, it examines whether changes in HIBOR futures prices, HKD forward foreign exchange rate premia, non-deliverable RMB forward prices, and implied volatility of Hang Seng (equity) index options signal changes in the aggregate balance. The impact of changes in the log of the aggregate balance on changes in: HIBOR, the HIBOR-LIBOR spread, the realized volatility of the Hang Seng Index, and stock returns are also examined. Moreover, the study examines the dynamic relationship between capital flows and the level and volatility of the stock market after taking into account the impact of large IPO issues.

Before delving into the empirical analysis it is often useful to get a sense of the behavior of the various financial market prices under examination. Figure 3 depicts the relationship between the level of the Hang Seng Index and realized volatility of the Hang Seng Index. Figure 4 depicts the behavior of total trading volume or turnover activity of stocks listed on the Main Board of the Hong Kong Stock Exchange. As is readily apparent, total trading volume increased substantially in 2006. Implied volatility provides a market-based measure of the probability distribution of returns. Figure 5 depicts the behavior of implied volatility from Hang Seng Index options during the 2004-2006 time periods.

Figure 6 depicts the relationship among overnight LIBOR, Overnight HIBOR, and the three-month HIBOR Futures. The apparent stair-step-like behavior of overnight LIBOR reflects the fact that it closely tracks the targeted Fed funds rate during normal markets.[19] The "steps" largely correspond to the 17 consecutive quarter point increases in the Fed funds rate during the time period when the Fed funds rate rose from 1% to 5.25%. Figure 6 shows that both overnight HIBOR and the daily three-month HIBOR futures price exhibit large variations in volatility in sharp contrast to overnight LIBOR.

Figure 7 depicts the behaviour of Hong Kong dollar spot and three-month forward exchange rates. As is readily apparent, Figure 7 displays periods of relative strength and weakness in the Hong Kong dollar exchange rate with the US dollar. Interestingly, the spread between the two rates narrowed sharply

[18] One consequence of the large amount of hot money parked in Hong Kong dollars in the pre-May 18, 2005 period is the near zero level of interest rates. This, in turn, may have encouraged additional IPO activity as companies sought to exploit the low financing costs. Indeed, Fung, Fung, Cheng, and Chan (2004) show that the financing cost is highly significant for buying stocks in frequently massively over-subscribed IPOs in Hong Kong due to the Asian style allocation process. Essentially, this process requires investors to post funds in a non-interest bearing account to cover the cost of all of the shares an investor has subscribed to even though it is unlikely that the investor will be awarded more than a small fraction of the shares bid for.

[19] For instance, Rosengreen (2008) notes that LIBOR "tracked closely with the Federal Funds rate target in the first half of 2007, but has been elevated since the onset of financial problems in late July 2007."

immediately after the Convertibility Undertakings in May 2005 and narrowed further after the revaluation of the RMB on July 21, 2005.

Figure 8 depicts the behaviour of the RMB spot and selected RMB non-deliverable forward (NDF) prices during the 2004-2006 period. It should be noted that during 2002, RMB NDF forward prices were above the prevailing spot exchange rate of 8.2769 to the US dollar. This suggests that forward market participants were anticipating a devaluation of the RMB against the US dollar during that time. Figure 8 suggests that there was some narrowing of the spread between forward contract months in the immediate aftermath of the decision by the Peoples Bank of China to revalue the renminbi on July 21, 2005, the impact on the difference in spreads across forward contract months was relatively short-lived.

This study is organized as follows. Section 2 reviews the relevant related literature. Section 3 summarizes the testable hypotheses, Section 4 describes the data and methodology of the study, Section 5 discusses the empirical analysis and Section 6 provides a summary and conclusions.

2. Literature Review

The nature of hot money remains controversial. While much research focuses on volatile short-term capital flows, Dooley *et al.* (1995) point out that long-term capital flows can also be quite volatile and unpredictable. Brennan and Aranda (1999) argue that the observed greater volatility of debt capital flows relative to equity capital flows can be explained, in part, by differential information held by domestic and foreign market participants. That is, the greater the informational advantage of domestic over foreign investors the more volatile are flows of debt capital relative to flows of equity capital.

Large portfolio capital flows have been found to be associated with increases in stock market turnover. Using the Portfolio Flow Indicator (PFI) compiled by State Street Bank, the Securities and Futures Commission's (SFC) (2006) recent study of six Asian markets (Australia, Hong Kong, Japan, Korea, Singapore, and Taiwan) indicates a positive relationship between capital inflows and stock market turnover. The study also reports that the estimated capital inflows into Hong Kong were the highest among all Asian markets for the period 2004 to the first quarter of 2006. The study attributes the large fund flows to the interests of overseas investors in H-shares and Red-chips that allow foreign participation in the Chinese equity market (i.e., the "China play"). Lee and Poon (2004a) finds that the listings of Mainland companies increase the market turnover of Hong Kong.[20] The study estimates that US$14.2 billion flowed into the Hong Kong stock market in the first quarter of 2006 alone. Moreover, the figure understates total fund flows into the Hong Kong market because the PFI captures only a subset of

[20] See Lee and Poon (2004b) for a study on the general impact of IPOs on the market turnover of Hong Kong.

international portfolio investment flows.[21] The study conjectures that higher fund flows can be associated with higher market volatility.

It should be pointed out that measuring hot money flows via the change in the level of portfolio investment may not fully reflect the nature and impact of the capital flows. The reason for this is that hot money may not move in and out of Hong Kong within a short period of time which can be captured by the change in the aggregate balance. For example, the aggregate balance hovered around HK$15.8 billion between December 2004 and early 2005 according to Yam (2005a). Similarly, Rea (1996) finds, from his study of the behavior of 13 large US emerging market funds (invested in a total of 23 emerging markets) from 1991 to 1996, that there were no significant redemption activities of these funds when the markets drop. Hence, it may be difficult to equate portfolio investment flows with hot money. Portfolio investment flows may represent long-term investments. As a result, this study not only examines how the change in the aggregate balance reflects the flow of foreign capital, it also examines the effect, if any, of the level of the aggregate balance on Hong Kong financial markets.

The lower transaction costs of, and significant implicit leverage in, derivatives securities, make futures and options the vehicles of choice for informed traders to take substantial market positions in order to profit from prospective changes in the prices and/or volatility of the underlying assets. Hence, both trading volume and open interest of derivative securities would be expected to rise in anticipation of large financial price movements. In addition to trading volume and open interest, the implied volatility from index options is also a potential source of information. Indeed, implied volatility can be viewed as a combination of market participants' forecasts of future market volatility. Poon and Granger (2005) find that implied volatility outperform time series models in predicting future volatility. Fung (2007) finds that the implied volatility from the Hong Kong Hang Seng index options provides an efficient forecast of future realized volatility for the period 1993 to 2000. The study also shows that a model that employs both implied and realized volatility measures provides statistically significant advance warning signals about abnormal future market volatility.[22] Moreover, it has been widely documented that there is a significant relationship between market volatility and the behavior of asset prices.

To be sure, not every increase in trading volume reflects the exploitation of advance information by market participants. Nor is the evidence always unambiguous. For instance, Poteshman (2006) reports that the unusually high level of long put trading volume on American and United Airlines stock in the days preceding the September 11, 2001 terrorist attacks on the World Trade Center and the Pentagon was "consistent with informed investors having traded options in advance of the attack." However, using other measures "designed to capture the ratio of short to long bets on the underlying stock" (that are also

[21] The Portfolio Flow Index reflects international fund flows resulting from securities transactions of institutional clients of State Street which covers 15% of the total value of the world's (tradable) securities.

[22] A number of studies especially of the US markets also show that option implied volatility provides signals prior to stock market crash. These studies include Bates (1991) and Rapport and White (1994).

adjusted for potential biases) and comparing option activity over a four day measure rather than a one day measure, Poteshman argues that the trading activity prior to September 11, 2001 "could hardly have been less unusual."

Although trading volume is believed to convey information the question arises as to whether the amount of information conveyed varies directly or inversely with the level of trading intensity. Put differently, is there more information conveyed during turbulent or tranquil periods? Lyons (1995) presents evidence that the relationship is inverse or negative in the foreign exchange market.

The notion that prices convey information is central to neoclassical economic theory. However, the notion that transactions in markets convey information is controversial. There are a substantial number of studies in the financial economic literature that suggest that order imbalances impact the behavior of financial market prices. For example, Lyons (2001) argues that conventional macroeconomic models fail to explain much of the variation in foreign exchange rates but finds that a model that includes order flow explains about 60 percent of the variation in foreign exchange rates. Similarly, Lyons and Moore (2005) suggest that the order flow in one market conveys information in related markets. In a recent study, Evans and Lyons (2006) advance a model in which differences across end users impacts the information content of order flow. An interesting result from their report is that approximately one-third of the explanatory power of order flow comes from its ability to predict future order flow.

Lyons, Ito, and Melvin (1998) demonstrate that private information may exist in markets that are often thought to be efficient—such as the foreign exchange market. They report evidence that the volatility of exchange rates increased following the introduction of trading over the Tokyo lunch hour.

Fung and Yu (2007) examine the impact that order imbalances have on the intraday behavior of stock index and stock index futures prices. They report evidence that order imbalances in the stock market "significantly affect the error correction dynamics of index and futures prices.

McNelis and Neftci (2006) investigate the question of what one "can learn about prospects of Renminbi (RMB) revaluation as well as Chinese share-market appreciation from daily financial market data?" The focus of their study differs from ours in that they are interested in "how much the sharp appreciation of the Euro against the US dollar [can] explain these developments." They examine the RMB NDF market and test the hypothesis that changes in the Euro/US dollar exchange rate are "the main determinant of the NDF discount observed in the RMB NDF market." They report evidence that suggests that RMB NDF prices are driven by the appreciation of the euro against the U.S. dollar. Specifically, they conclude: "The Renminbi NDF is driven by its own dynamics and only by the Euro-Dollar exchange rate… As the Euro appreciates, the Renminbi discount in the NDF market becomes more negative…."

Finally, there is issue of the effectiveness of alternative approaches of responding to speculative attacks associated with hot money flows. Edison and Reinhart (2001) examine the efficacy of using capital controls to stop speculative attacks arising from hot money flows. They examine the imposition of capital controls by Brazil, Thailand and Malaysia and find that only in the case of Malaysia were the capital controls effective.

3. Testable Hypotheses

The testable hypotheses examined in this study fall into three principal categories. The first category consists of hypotheses about the relationship between changes in the aggregate balance and changes in various financial market variables such as spot exchange and interest rates, stock market return and volatility. The second category consists of hypotheses about the relationship between changes in various derivative market prices or option implied volatility and changes in the aggregate balance. The third set of hypotheses consists of an examination of relationships between various variables considered in the first two categories of hypotheses that do not include changes in the aggregate balance, for example, changes in implied stock market volatility and realized market stock volatility, changes in the RMB NDF prices and stock returns, or changes in the RMB NDF prices and changes in HKD forward exchange rates. That is, this study attempts to answer two questions. First, do changes in the aggregate balance affect financial market variables? And, second, do derivative markets contain useful information for signaling changes in the aggregate balance?

3.1 Financial Market Variables and the Aggregate Balance

Other things equal, a capital inflow should cause the Hong Kong dollar to strengthen against the US dollar while a capital outflow should cause the Hong Kong dollar to weaken against the US dollar. This leads naturally to the following hypotheses.

Hypothesis 1: The Spot Exchange Rate and the Aggregate Balance

$H_{0:}$ Changes in the aggregate balance do not presage a change in the spot exchange rate in the opposite direction.

$H_{A:}$ Changes in the aggregate balance presage a change in the spot exchange rate in the opposite direction.

Similarly, a capital inflow should lead to a larger monetary base and lower interest rates while a capital outflow would do the opposite. Likewise, the spread between HIBOR and LIBOR would widen with a capital inflow and narrow with a capital outflow. This leads naturally to the second and third hypotheses.

Hypothesis 2: The Overnight Interest Rate and the Aggregate Balance

$H_{0:}$ Changes in the aggregate balance do not presage a change in the spot overnight interest rate, HIBOR, in the opposite direction.

$H_{A:}$ Changes in the aggregate balance presage a change in the spot overnight interest rate, HIBOR, in the opposite direction.

Hypothesis 3: The Overnight HIBOR-LIBOR Spread and the Aggregate Balance

$H_{0:}$ Changes in the aggregate balance do not presage a change in the spread between spot HIBOR and LIBOR in the opposite direction.

$H_{A:}$ Changes in the aggregate balance presage a change in the spread between spot HIBOR and LIBOR in the opposite direction.

If a capital inflow leads to foreign investors buying Hong Kong stocks then the total trading turnover in Hong Kong stocks should increase with such buying. The opposite is true for capital outflows. This leads naturally to the following hypotheses.

Hypothesis 4: Stock Returns and the Aggregate Balance

$H_{0:}$ Changes in the aggregate balance do not presage a change in stock market turnover in the same direction.

$H_{A:}$ Changes in the aggregate balance presage a change in stock market turnover in the same direction.

Similarly, if capital inflows lead to more foreign stock market purchases then stock market volatility should increase. The converse is true for capital outflows.[23] Changes in the aggregate balance should both lead and lag realized market volatility. This leads to the following hypotheses.

Hypothesis 5: Realized Stock Market Volatility and the Aggregate Balance

$H_{0:}$ Changes in the aggregate balance do not presage a change in realized stock market volatility in the same direction.

$H_{A:}$ Changes in the aggregate balance presage a change in realized stock market volatility in the same direction.

3.2 Aggregate Balance and Derivative Market Variables

If derivative markets contain useful information for signaling the aggregate balance then changes in various derivative market prices should precede changes in the aggregate balance. Central to the

[23] While the relationship between changes in the aggregate balance and stock market volatility or turnover is straightforward the relationship between changes in the aggregate balance and stock return is ambiguous. The relationship is difficult to determine a priori and could go either way as it depends, in part, on the timing of the cash flows. An examination of changes in the aggregate balance and stock returns fails to reveal any significant relationship.

operation of the currency board is the notion that capital inflows will reduce short-term interest rates while capital outflows will increase short-term interest rates. Financial theory suggests that interest rate futures markets would anticipate the effect of an increase or decrease in the aggregate balance on interest rates. This leads to the following hypotheses.

Hypothesis 6: The Aggregate Balance and Three-Month HIBOR Futures Prices

$H_{0:}$ An increase (decrease) in the three-month HIBOR futures prices does not presage a large capital inflow (outflow) as measured by a change in the aggregate balance one or more days ahead.

$H_{A:}$ An increase (decrease) in the three-month HIBOR futures prices does presage a large capital inflow (outflow) as measured by a change in the aggregate balance one or more days ahead.

Given that a capital inflow (outflow) should strengthen (weaken) the Hong Kong dollar relative to the US dollar, financial theory would suggest that the impact of a large capital flow might show up in the behaviour of the HKD forward exchange rate. That, is the forward exchange rate would fall (strengthen) against the dollar with a large capital inflow and rise (weaken) with a large capital outflow. This leads to the following hypotheses.

Hypothesis 7: Aggregate Balance and Three-Month HKD Forward Exchange Rate

$H_{0:}$ A decrease (increase) in the three-month Hong Kong dollar forward exchange rate does not presage an increase (decrease) in the aggregate balance one or more days ahead.

$H_{A:}$ An decrease (increase) in the three-month Hong Kong dollar forward exchange rate does presage an increase (decrease) in the aggregate balance one or more days ahead.

Alternatively stated, theory suggests that any differential between HKD and USD interest rates should be insignificant. However, the expectation by market participants that the Hong Kong dollar will appreciate triggers hot money flows (as evidenced by the forward premium) which increases the aggregate balance and forces the interbank interest rate down. Simply put, this means that the forward premium or HKD forward exchange rate is driving the interest rate differential. It also suggests that there should be a lead/lag relationship between the aggregate balance and the forward premium due to the interest rate differential. Any action which reduces the likelihood of appreciation of the Hong Kong dollar against the US dollar—such as the Convertibility Undertakings—reduces speculation on the appreciation of the HKD which should cause both the HKD forward premium and interest rate differential to disappear.[24]

[24] As Yam (2007) notes, anomalies may arise in the relationship between the HKD/USD interest rate differential and HKD/USD exchange rate due to uncertain liquidity demand in the face of fixed liquidity supply (i.e., aggregate balance). Such a situation arose during Fall 2007.

Changes in option-implied volatility should both lead and lag changes in the aggregate balance. That is, informed traders take positions in the option market prior to the change in the aggregate balance, and other option participants take the change in aggregate balance as new information in revising the option prices (or anticipated market volatility). A recent SFC study (2006) presents evidence that stock market turnover increases with portfolio inflows. The study also conjectures that higher fund inflows may be associated with higher market volatility. Implied volatility should lead the aggregate balance; the relationship should be shortened after the undertaking since hot money can move in shortly before speculators take market actions. If such a relationship exists it should be reflected in derivative markets first. This lends itself to the following null and alternative hypotheses.

Hypothesis 8: Implied Volatility and the Aggregate Balance

$H_{0:}$ An increase (decrease) in the implied volatility of Hang Seng equity index options does not presage a large capital inflow (outflow) as measured by a change in the aggregate balance three or more days ahead and is not shortened after the Convertibility Undertakings. (Remember that Hong Kong employs a T + 2 settlement system.)

$H_{A:}$ An increase (decrease) in the implied volatility of Hang Seng equity index options presages a large capital inflow (outflow) as measured by a change in the aggregate balance three or more days ahead and is shortened after the Convertibility Undertakings.

3.3 Derivative Market and Spot Financial Market Variables

The third category of hypotheses concerns relationships between selected derivative market and spot financial market variables. The following hypotheses are examined.

Hypothesis 9: Deviation of the Spot HKD Exchange Rate from 7.8 and Six-Month RMB NDF Prices

$H_{0:}$ An increase (decrease) in six-month RMB NDF prices does not lead an increase (decrease) in the deviation of the spot HKD exchange rate from the linked exchange rate of 7.8.

$H_{A:}$ An increase (decrease) in six-month RMB NDF prices leads an increase (decrease) in the deviation of the spot HKD exchange rate from the linked exchange rate of 7.8.

Hypothesis 10: Implied Stock Market Volatility and Realized Market Volatility

$H_{0:}$ An increase (decrease) in implied stock market volatility does not lead an increase (decrease) in realized stock market volatility by one or more days.

$H_{A:}$ An increase (decrease) in implied stock market leads an increase (decrease) in realized stock market volatility by one or more days.

The period examined includes a period of intense speculation on a revaluation of the renminbi. Changes in RMB NDF term premium should lead the aggregate balance. The July 21, 2005 announcement of the revaluation of the RMB should affect the strength of the lead-lag relationship.

Hypothesis 11: Six-Month RMB NDF Prices and Three-Month HKD Exchange Rates

$H_{0:}$ An increase (decrease) in six-month RMB NDF prices does not lead an increase (decrease) in three-month HKD exchange rates by one or more days.

$H_{A:}$ An increase (decrease) in six-month RMB NDF prices leads an increase (decrease) in three-month HKD exchange rates by one or more days.

Hypothesis 12: Six-Month RMB NDF Prices and Hong Kong Stock Market Returns

$H_{0:}$ An increase (decrease) in six-month RMB NDF prices does not lead an increase (decrease) in the return on the Hong Kong stock market by one or more days.

$H_{A:}$ An increase (decrease) in six-month RMB NDF prices leads an increase (decrease) in the return on the Hong Kong stock market by one or more days.

4. Data and Methodology

4.1 Data

We use daily data covering the period January 2, 2004 through December 29, 2006. The dataset includes: the closing aggregate balance as reported by the HKMA; three-month HIBOR interest rate futures contracts for the month closest to expiration; Hang Seng Index futures contracts for the month closest to expiration; overnight US dollar LIBOR and HIBOR rates; implied market volatility from the spot and next month Hang Seng Index options contracts. The study focuses on the spot and next month contracts since according to Draper and Fung (2003) they are most actively traded and liquid. Following Fleming, Ostdiek, and Whaley (1995), we adjust for the bias in volatility arising from prices simply bouncing between bid and ask (i.e., the bid-ask price bounce) by using the middle of the bid and ask quotes for both options and futures for all relevant measures. Other data examined in the study include: daily turnover of the main, minute-by-minute reported stock index from the HSI Services; daily data on foreign exchange purchases and sales by the HKMA.

4.2 Methodology - Construction of Implied Volatility Index

The model-based implied volatility index from the spot and next-month Hang Seng Index option contracts are used. The spot and next-month options and futures contracts share identical expiration dates and

common settlement prices against the cash index. These features allow the options to be priced as if they are futures options. For instance, the terminal value of the call option on the cash index (*S*) is equal to Max [0, S_T -*X*]; while the value of the call option on the index futures with the same strike price (*X*) is equal to Max [0, F_T -*X*]. Since F_T converges to S_T at expiration, the two options have identical value. This can be easily seen if one assumes that the futures price can be described by a geometric Brownian motion. Black's (1976) European futures options model can be directly applied to price the option with the index futures (Duan and Zhang, 2001; Draper and Fung, 2003). The same argument applies to the put option. Consider, for instance, the old CBOE VIX index,

$$C_t(X,T) = e^{-r(T-t)}\left[F_t(T)N(d_t) - XN\left(d_t - \sigma_t\sqrt{T-t}\right)\right] \text{ and}$$
$$P_t(X,T) = e^{-r(T-t)}\left[XN\left(-d_t + \sigma_t\sqrt{T-t}\right) - F_t(T)N(-d_t)\right]$$

where $C_t(X,T)$ and $P_t(X,T)$ denote call and put prices on day *t*, *T* denotes the expiration day, *X* denotes the exercise price, and F_t the synchronous index futures price, r the risk-free interest rate for the period, $d_t = \left[\ln(F_t(T)/X) + (1/2)\sigma_t^2(T-t)\right]/\sigma_t\sqrt{T-t}$, and *N*(.) represents the standard normal distribution. σ_t^2 represents the volatility of the futures price implied by the options price for the period between t and T. The futures options approach lessens the effect of the cost hurdle against arbitrage and avoids the impact of the constraints against short-selling of cash stocks. Because the HKEx employs a futures-style margining system for the index options, then, following Liu (1990), Chen (1993), and Duan and Zhang (2001), the above futures options formula can be further simplified as follows:

$$C_t(X,T) = \left[F_t(T)N(d_t) - XN\left(d_t - \sigma_t\sqrt{T-t}\right)\right] \text{ and}$$
$$P_t(X,T) = \left[XN\left(-d_t + \sigma_t\sqrt{T-t}\right) - F_t(T)N(-d_t)\right]$$

This framework allows us to price the Hang Seng equity Index options directly against the Hang Seng Index futures price. Moreover, the framework is independent of dividend payments to the index stocks and market interest rates. The implied volatilities are derived from active options quotes and synchronous middle quotes of the corresponding futures. The spot month implied volatility index is calculated as the average of all implied volatilities from the spot month contracts observed within the last 15 minutes before the cash market close. The next month implied volatility index is obtained in a similar manner. The implied volatility index used in the analysis contains largely the spot month volatility index except that the next month index is used during the last five trading days of the spot month contract.

5. Empirical Analysis

Corresponding to the three categories of hypotheses there are three major parts of the empirical analysis. The first part addresses the question of whether changes in the aggregate balance impact various financial market variables. The second part tries to answer the question posed in the title. Namely, do derivative markets contain useful information for signaling the timing of hot money flows (using changes in the aggregate balance as a proxy)? The third part examines the relationship between various derivative market variables and selected cash market variables. These include lead-lag relationships between: market volatility and realized market volatility; six-month NDF RMB prices and three-month HKD exchange rates; and six-month NDF RMB prices and the stock returns on the Hong Kong market. Central to the empirical analysis is the assumption that the adoption of the Convertibility Undertakings by the HKMA on May 18, 2005 was tantamount to a regime change. Consequently, switching regressions are used to examine the relationships.

5.1 Do Changes in the Aggregate Balance Impact Financial Market Variables?

As noted above, there is reason to believe that changes in the aggregate balance could presage changes in the realized volatility of the cash stock market. The argument is that if overseas investors are interested in investing in the Hong Kong stock market they need to accumulate Hong Kong dollars in advance of their investment or take a position in the derivatives market. To be sure, the fixed exchange rate means that there is minimal exchange rate risk for US dollar based investors. Presumably, the only reason foreign investors are buying Hong Kong stocks is that they anticipate the market rising. The inflow of foreign money into the stock market may increase realized volatility in the stock market.

Table 1 displays the results of a switching regression on the relationship between stock market volatility and the change in the log of the aggregate balance. Although the results are somewhat mixed (as one coefficient is negative), Table 1 suggests that changes in the log of the aggregate balance leads changes in realized market volatility by up to five trading days.[25] The fact that changes in the aggregate balance tend to lead changes in cash market stock volatility might be explained by the need for foreign investors to accumulate Hong Kong dollars in advance of taking cash market positions in the Hong Kong stock market. After the regime switch, the sign on the coefficient for the fifth trading day lead variable is negative. This suggests that the leading relationship has substantially weakened. Stock market volatility is substantially lower after the Convertibility Undertakings. Alternatively stated, changes in the aggregate balance are no longer a substantial source of market volatility.

The question naturally arises as to whether changes in the log of the aggregate balance predict changes in stock market turnover. The relationship is examined in Table 2. An analysis of the results of the

[25] White's Heteroskedasticity-Consistent standard errors are used to calculate t-statistics.

switching regression between changes in stock market turnover (defined as the difference in the natural logarithm of total turnover of Main Board stocks listed on the Stock Exchange of Hong Kong) and changes in the aggregate balance (defined as the difference in the natural logarithm of the aggregate balance) suggests that there is strong evidence that changes in the aggregate balances lead stock market turnover by two days. The coefficient is both positive and significant.

This study began with a discussion of how changes in the aggregate balance impact changes in interest rates. Namely, an increase in the aggregate balance reduces the interbank interest rate and a decrease in the aggregate balance increases the interbank interest rate. This relationship suggests that one should see a negative relationship between changes in the log of the aggregate balance and interbank interest rate—HIBOR. Moreover, it also suggests that the difference or spread between US dollar interest rates and Hong Kong dollar interest rates may widen as the log of the aggregate balance increases and narrow as the log of the aggregate balance falls.

These relationships are tested in Tables 3 and 4. Table 3 displays the results of a switching regression on changes in the overnight HIBOR (defined as the difference in the natural logarithm of overnight HIBOR) and changes in the aggregate balance (defined as the difference in the natural logarithm of the aggregate balance). As is readily apparent, there is a strong negative contemporaneous relationship between changes in HIBOR and changes in the aggregate balance both before and after the switch. That is, an increase in the aggregate balance puts downward pressure on HIBOR as theory suggests. Table 3 suggests that the effect weakens after the switch. The coefficients for the lead two terms are also significant both before and after the switch but change signs. This means that changes in HIBOR lead changes in the aggregate balance by two trading days. The significant positive coefficient means that a decrease in HIBOR causes a decrease in the aggregate balance (i.e., an outflow of hot money) and vice versa. Simply put, both the contemporaneous relationship and the lead-lag relationship between HIBOR and aggregate balance are weakened after the Convertibility Undertakings. This means that the impact of the aggregate balance on the HIBOR level is substantially reduced after the undertaking. The result might be attributed to the stability of the aggregate balance level after the undertaking and the renewed incentives to conduct interest rate arbitrage.[26]

Table 4 displays the results of a switching regression on the spread or difference between overnight HIBOR and LIBOR. Consistent with results from Table 3, Table 4 displays a strong negative contemporaneous relationship between changes in the spread and changes in the aggregate balance. Table 4 shows that changes in HIBOR-LIBOR spread also lead the aggregate balance. The strong negative contemporaneous relationship before the Convertibility Undertakings is consistent with the

[26] HKMA, Monetary Management and Infrastructure Department, Quarterly Bulletin, "Operation of Monetary Policy," September 2005. The Bulletin states: "The refinements to the Linked Exchange Rate system effectively eliminated the uncertainty about how much the Hong Kong dollar can strengthen, revitalizing interest rate arbitrage activities and helping to align Hong Kong dollar interest rates with U.S. counterparts." Page 44.

results shown in Table 3 and indicates that an increase in aggregate balance lowers both overnight HIBOR as well as the spread between HIBOR and the corresponding US dollar LIBOR, and vice versa. This spread is weakened after the Convertibility Undertakings for reasons similar to HIBOR mentioned above. Table 4 also suggests that there is a strong relationship for the second and third lead terms before and after the regime switch. The coefficients are negative for three of the four lead terms.

Table 5 displays the relationship between changes in the deviations of the spot exchange rate of the Hong Kong dollar from 7.80 (defined as the difference in the natural logarithm of the deviation of the HKD spot exchange rate from the linked rate of 7.80) and changes in the aggregate balance (defined as the difference in the natural logarithm of the aggregate balance).[27] There is a strong negative contemporaneous relationship. This indicates that the aggregate balance builds up when the Hong Kong dollar strengthens (against the linked rate). Table 5 also indicates that the HKD spot exchange rate leads the aggregate balance by four trading days. The positive coefficient builds up as the Hong Kong dollar strengthens and vice versa. Table 5 also indicates that there is an even more significant negative coefficient for the four day lead term after the Convertibility Undertakings. This relationship strengthens after the Convertibility Undertakings.

5.2 Derivative Market and Spot Market Relationships

Table 6 reports the results of a switching regression between realized market volatility (defined as the absolute value of the difference in the natural logarithm of the Hang Seng Index) and realized market volatility and implied market volatility (defined as the difference in the natural logarithm of the implied volatility from the Hang Seng Index options). The Table shows that implied volatility leads realized volatility by seven trading days. Perhaps surprisingly, Table 6 suggests that realized volatility leads implied volatility after the regime switch by three to five days.

Table 7 examines relationship between changes in the deviation of the HKD spot exchange rate from the linked rate of 7.80 and changes in the forward premium of the six-month RMB NDF (defined as the difference in the natural logarithm of the forward premium of the six-month RMB NDF.) Table 7 shows an exceptionally strong positive contemporaneous relationship between the two variables. The t-statistic is 4.82. The first lag term is also statistically significant. The relationship weakens considerably after the Convertibility Undertakings. This suggests that the use of the Hong Kong dollar as a vehicle to speculate on the RMB has been substantially diminished.

Table 8 examines the lead-lag relationship between six-month RMB NDF prices and three-month HKD exchange rates. It shows a very strong positive contemporaneous relationship before the Convertibility Undertakings. In addition, six-month RMB NDF prices lead changes in the three month HKD exchange

[27] The spot exchange rate of the Hong Kong dollar did not trade above 7.80 during the time period of this study.

rate by one day as well. This suggests that the HKD and HKD denominated assets were used as a proxy for speculation on the RMB before the Convertibility Undertakings.

Table 9 reports the results of an examination of the lead-lag relationships between changes in stock returns (defined as the difference in the natural logarithm of the Hang Seng stock index) and changes in six-month RMB NDF prices (defined as the difference in the natural logarithm of six month RMB NDF prices). It suggests that there is a strong positive contemporaneous relationship between the two variables. It also suggests that changes in RMB NDF forward prices led changes in stock returns by two, three, and four days before the Convertibility Undertakings. The relationship is positive. This suggests that the Hong Kong stock market was used as a proxy for speculation on a revaluation of the renminbi. There is also some evidence that RMB NDF prices both lead and lag changes in stock returns. However, the evidence that changes in RMB NDF prices lead changes in stock returns is stronger than the evidence that RMB NDF prices lag changes in stock returns. Note that the aforementioned relationships are largely unchanged after the Convertibility Undertakings.

5.3 Do Derivative Markets Help Signal Changes in the Aggregate Balance?

The second major part of the empirical analysis examines whether changes in selected derivative market prices contain useful information for predicting changes in the aggregate balance.

Table 10 displays the results of a switching regression between changes in the aggregate balance (defined as the difference in the log of the daily closing value of the aggregate balance) and changes in three-month HIBOR futures prices (defined as the difference in the natural logarithm of the three month HIBOR futures price). Table 10 suggests that changes in the three-month HIBOR futures prices lead changes in aggregate balance by three trading days and the relationship is positive. The coefficients on the first three lagged variables are significant. Since the implied three-month HIBOR future interest rate is equal to one minus the futures price, the result shows that an increase in the implied future interest rate precedes a prospective fall in the aggregate balance, and vice versa. The relationship is largely unchanged. After the undertaking the result suggests that changes in the aggregate balance lead changes in HIBOR by five days. The post-switch result is puzzling but unlikely to be a profitable trading opportunity.

Table 11 shows the lead-lag relationship between changes in aggregate balance (defined as the difference in the natural logarithm of the daily closing aggregate balance) and changes in the three-month HKD forward exchange rate. Consistent with results of HIBOR futures, changes in the HKD forward exchange rate leads changes in the aggregate balance but only by a single trading day. The positive coefficient implies that a decrease in the three-month HKD forward exchange rate (i.e., a strengthening of HKD) indicates future increase in the aggregate balance, and vice versa. Note that all lagged terms before the regime change share the same sign. The leading relationship is largely unchanged after the

regime switch. Table 11 suggests changes in the aggregate balance lead changes in the three-month HKD forward exchange rate by two days. As with Table 10, this relationship is unlikely to suggest a profitable trading strategy in financial markets.

Table 12 shows the lead-lag relationship between changes in implied volatility of Hang Seng Index options and changes in the aggregate balance (defined as the difference in the natural logarithm of the daily closing value of the aggregate balance). Table 12 shows that changes in implied volatility lead changes in the aggregate balance by five trading days. The coefficient is positive and consistent with expectations. The relationship between changes in implied volatility and changes in the aggregate balance is not impacted by the Convertibility Undertakings.[28]

As a robustness check, we examine the relationship in a multiple equation framework to account for interrelationship between the variables. The augmented Dickey Fuller tests show that all variables being studied are non-stationary and the null hypothesis of unit root cannot be rejected. The Johansen trace and eigenvalue tests indicate that there is no cointegration relationship between the variables. Therefore, a standard Vector Autoregression (VAR) model without error correction mechanism is adopted for the multi-equation analysis.

Table 13 reports the Granger causality tests for the changes in aggregate balance and the financial market variables. The results are derived from a VAR model with two lags selected by Akaike Information Criterion. Each column together with the p-values represents the estimates from the corresponding equation. All interaction variables with the switching indicator are not significant and not reported. The first point worth noting is that the first column shows none of the financial market variables Granger causes the aggregate balance to change. On the other hand, the causality test confirms that the aggregate balance leads the change in the overnight HIBOR and the relationship is significant at the 1% level.

The Granger causality tests for the aggregate balance and the derivative market variables are presented in Table 14. The aggregate balance equation shows that only the three-month HKD forward exchange rate Granger causes the aggregate balance to change with a p-value of 0.01. The relationship is confirmed by the rejection of aggregate balance leads the three-month HKD forward rate with the F statistic of 0.8618 and p-value of 0.50. None of the other derivative market variables reports a direct causal relationship with the aggregate balance. However, the results of the three-month HKD forward rate equation in column three reveal that the forward rate is driven by the three month HIBOR futures prices and the six-month RMB NDF prices. For the case of HIBOR futures prices, no conclusion can be made because the test also shows that three-month HKD forward rate Granger causes HIBOR futures prices. In

[28] It should be noted that the Convertibility Undertakings, by reducing the potential benefit from hoarding Hong Kong dollars, may obscure the relationship between the (closing) aggregate balance and prospective market activities (i.e., "hot money"). That is, hot money flows may affect the intraday aggregate balance but not the closing aggregate balance. An examination, however, of both the daily range of the aggregate balance and daily change in the monetary base did not indicate a statistically significant relationship.

the case of the six-month RMB NDF prices, the hypothesis of the six-month RMB NDF prices leading the forward rate is clearly rejected. This result implies that the six-month RMB NDF prices directly affects changes in the three-month HKD forward rate in turn indirectly affecting the changes in the aggregate balance. In conclusion, the Granger causality tests from the VAR model reveal that the three-month HKD forward rate and the six-month RMB NDF prices help to predict movements in aggregate balance.

6. Conclusions

Sudden changes in capital flows can induce sharp changes in interest rates that, in turn, impact the equity market and economic activity in an economy whose monetary authority pursues a stable exchange rate policy like Hong Kong. We classify these sudden changes in capital flows as "hot money." The effects of "hot money" and other large capital flows complicate the tasks of the Hong Kong Monetary Authority and the SFC. We examine the question of whether changes in derivative market prices contain useful information in signaling changes in hot money by examining a commonly agreed period of intense speculation on the RMB that includes significant policy actions by the HKMA and the Peoples Bank of China.

Central to the empirical analysis is the assumption that the adoption of the Convertibility Undertakings by the HKMA on May 18, 2005 was tantamount to a regime change. Consequently, switching regressions are used to examine the potential relationships among variables of interest. This study provides evidence that selected derivative market prices contain useful information on the timing of potential "hot money" capital flows (i.e., useful information for signaling changes in the aggregate balance). Granger causality tests controlling for interrelationships between the variables reach the same conclusion. Although the research is exploratory, the results suggest that the HKMA and other regulatory authorities might possibly use readily available financial market prices to extract information on impending large capital flows. Such information may allow the government to devise pre-emptive measures in order to reduce the impact of such movements on Hong Kong financial markets and to assure the continued stability of the Linked Exchange Rate system.

The May 18, 2005 refinements to the Linked Exchange Rate system appear to have reduced the impact of changes in the aggregate balance on Hong Kong financial markets. However, the information content of derivative markets for signaling changes in the aggregate balance remains strong. Changes in derivative prices remain good signals.

The amount of speculation appears to have diminished since the Convertibility Undertakings given the relative stability of the aggregate balance. However, the results suggest that one can still determine the direction and timing of speculative cash flows even though the absolute amount of speculation may be far smaller. It is also possible that Hong Kong could endure another wave of hot money capital flows should

market participants believe that the Linked Exchange Rate system may be abandoned or the dollar replaced with another currency.

To be sure, some puzzles remain. This study focused on hot money flows associated with speculation of a revaluation of the renminbi. It largely ignores the impact of IPO activity on the aggregate balance. This is a subject for further research.

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Table 1. Lead-Lag Relationship between Aggregate Balance and Market Volatility

Dependent Variable: ABSDLNHSI (absolute value of the difference in natural logarithm of the Hang Seng Index)

Independent Variable: DLNAB (difference in natural logarithm of the aggregate balance)

Variable	Coefficient	t-Statistic	Prob.
C	0.007789	15.41054	0.0000
DLNAB	0.003221	0.707482	0.4796
DLNAB(-1)	-0.000569	-0.125629	0.9001
DLNAB(-2)	0.005861	1.752528	**0.0802**
DLNAB(-3)	-0.009343	-1.770363	**0.0772**
DLNAB(-4)	-0.001746	-0.391480	0.6956
DLNAB(-5)	0.007266	1.997254	**0.0463**
SWITCH	-0.001479	-2.387657	**0.0173**
SWITCH*DLNAB	0.000283	0.057629	0.9541
SWITCH*DLNAB(-1)	0.000633	0.130356	0.8963
SWITCH*DLNAB(-2)	-0.006245	-1.614375	0.1070
SWITCH*DLNAB(-3)	0.007588	1.335045	0.1824
SWITCH*DLNAB(-4)	0.001666	0.338016	0.7355
SWITCH*DLNAB(-5)	-0.009472	-2.282020	0.0229
AR(1)	-0.050807	-1.361255	0.1740
AR(2)	0.004892	0.099037	0.9211
AR(3)	0.063108	1.326718	0.1851
AR(4)	-0.030471	-0.665654	0.5059
AR(5)	0.104952	2.056104	0.0402
R-squared	0.046926		
Adjusted R-squared	0.017194		
F-statistic	1.578313		
Prob(F-statistic)	0.060338		

Table 2. Lead-Lag Relationship between Aggregate Balance and Total Stock Turnover

Dependent Variable: DLNTURNOVER (difference in natural logarithm of total turnover of Main Board stocks listed on the Stock Exchange of Hong Kong)

Independent Variable: DLNAB (difference in natural logarithm of the aggregate balance)

Variable	Coefficient	t-Statistic	Prob.
C	-0.001862	-0.401513	0.6882
DLNAB(5)	-0.025985	-0.145840	0.8841
DLNAB(4)	-0.083931	-0.406950	0.6842
DLNAB(3)	-0.066363	-0.354926	0.7228
DLNAB(2)	-0.037914	-0.261713	0.7936
DLNAB(1)	0.138378	0.834993	0.4041
DLNAB	0.026600	0.169316	0.8656
DLNAB(-1)	-0.164434	-0.753123	0.4517
DLNAB(-2)	0.380924	**1.827100**	**0.0682**
DLNAB(-3)	-0.240138	-1.254264	0.2103
DLNAB(-4)	0.207644	1.099150	0.2722
DLNAB(-5)	-0.098252	-0.664009	0.5070
SWITCH	0.006058	1.006945	0.3144
SWITCH*DLNAB(5)	0.018594	0.095740	0.9238
SWITCH*DLNAB(4)	0.143183	0.634004	0.5263
SWITCH*DLNAB(3)	0.166024	0.813237	0.4164
SWITCH*DLNAB(2)	0.042402	0.287245	0.7740
SWITCH*DLNAB(1)	-0.114666	-0.638467	0.5234
SWITCH*DLNAB	0.033310	0.195954	0.8447
SWITCH*DLNAB(-1)	0.206677	0.898853	0.3691
SWITCH*DLNAB(-2)	-0.336215	-1.530498	0.1265
SWITCH*DLNAB(-3)	0.135252	0.665907	0.5057
SWITCH*DLNAB(-4)	-0.252885	-1.226699	0.2204
SWITCH*DLNAB(-5)	0.130642	0.765742	0.4442
AR(1)	-0.534039	-11.70721	0.0000
AR(2)	-0.461026	-9.528026	0.0000
AR(3)	-0.346533	-6.596434	0.0000
AR(4)	-0.266694	-5.315034	0.0000
AR(5)	-0.057702	-1.743767	0.0817
R-squared	0.274649		
Adjusted R-squared	0.238511		
F-statistic	7.599915		
Prob(F-statistic)	0.000000		

Table 3. Lead-Lag Relationship between Aggregate Balance and HIBOR

Dependent Variable: DLN(HIBOR) (difference in natural logarithm of the over-night HIBOR)
Independent Variable: DLNAB (difference in natural logarithm of the aggregate balance)

Variable	Coefficient	t-Statistic	Prob.
C	-0.021728	-0.699782	0.4844
DLNAB(5)	0.055653	0.289012	0.7727
DLNAB(4)	0.029086	0.125776	0.9000
DLNAB(3)	-0.147824	-0.814501	0.4157
DLNAB(2)	0.450052	**1.921154**	**0.0552**
DLNAB(1)	-0.148331	-0.394987	0.6930
DLNAB	-1.690407	**-3.160937**	**0.0017**
DLNAB(-1)	-0.375874	-1.254401	0.2102
DLNAB(-2)	-0.401367	-1.034687	0.3013
DLNAB(-3)	-0.007628	-0.027679	0.9779
DLNAB(-4)	-0.018600	-0.046590	0.9629
DLNAB(-5)	-0.068888	-0.221911	0.8245
SWITCH	0.023223	0.746644	0.4556
SWITCH*DLNAB(5)	-0.068040	-0.351977	0.7250
SWITCH*DLNAB(4)	-0.058398	-0.244820	0.8067
SWITCH*DLNAB(3)	0.078461	0.419590	0.6750
SWITCH*DLNAB(2)	-0.546264	-2.368426	0.0182
SWITCH*DLNAB(1)	0.060048	0.158726	0.8739
SWITCH*DLNAB	1.625754	3.027417	0.0026
SWITCH*DLNAB(-1)	0.322445	1.074889	0.2829
SWITCH*DLNAB(-2)	0.373830	0.961977	0.3365
SWITCH*DLNAB(-3)	-0.034305	-0.124163	0.9012
SWITCH*DLNAB(-4)	0.031574	0.078970	0.9371
SWITCH*DLNAB(-5)	0.078040	0.251158	0.8018
AR(1)	-0.327952	-1.682672	0.0930
AR(2)	-0.303047	-3.470147	0.0006
AR(3)	-0.101917	-1.256793	0.2094
AR(4)	-0.035139	-0.646797	0.5180
AR(5)	-0.056379	-0.655768	0.5123
R-squared	0.165342		
Adjusted R-squared	0.122144		
F-statistic	3.827501		
Prob(F-statistic)	0.000000		

Table 4. Lead-Lag Relationship between Aggregate Balance on HIBOR-LIBOR Spread

Dependent Variable: D(HIBOR-LIBOR) (difference in over-night HIBOR and over-night US-LIBOR)
Independent Variable: DLNAB (difference in natural logarithm of the aggregate balance)

Variable	Coefficient	t-Statistic	Prob.
C	-0.006594	-0.600104	0.5487
DLNAB(5)	-0.052724	-0.763052	0.4458
DLNAB(4)	0.012778	0.180679	0.8567
DLNAB(3)	-0.173789	**-1.919397**	**0.0554**
DLNAB(2)	0.225019	**1.851245**	**0.0647**
DLNAB(1)	0.222249	1.107030	0.2688
DLNAB	-0.475201	**-3.776382**	**0.0002**
DLNAB(-1)	-0.148713	-1.630572	0.1035
DLNAB(-2)	-0.078660	-0.459391	0.6461
DLNAB(-3)	-0.006320	-0.049706	0.9604
DLNAB(-4)	-0.027571	-0.229666	0.8184
DLNAB(-5)	-0.018572	-0.158235	0.8743
SWITCH	0.003814	0.279128	0.7802
SWITCH*DLNAB(5)	0.054366	0.593039	0.5534
SWITCH*DLNAB(4)	-0.001098	-0.010569	0.9916
SWITCH*DLNAB(3)	0.024212	0.184340	0.8538
SWITCH*DLNAB(2)	-0.412343	**-2.698548**	0.0072
SWITCH*DLNAB(1)	-0.389434	-1.715244	0.0869
SWITCH*DLNAB	0.341224	**1.973885**	**0.0489**
SWITCH*DLNAB(-1)	0.008028	0.064579	0.9485
SWITCH*DLNAB(-2)	0.007816	0.041824	0.9667
SWITCH*DLNAB(-3)	-0.104720	-0.754241	0.4510
SWITCH*DLNAB(-4)	0.095055	0.708617	0.4789
SWITCH*DLNAB(-5)	0.049113	0.375469	0.7075
AR(1)	-0.158080	-1.238494	0.2160
AR(2)	-0.092038	-1.288927	0.1980
AR(3)	-0.116394	-2.645904	0.0084
AR(4)	-0.048905	-0.722938	0.4700
AR(5)	0.028929	0.385653	0.6999
R-squared	0.082390		
Adjusted R-squared	0.036673		
F-statistic	1.802160		
Prob(F-statistic)	0.007488		

Table 5. Lead-Lag Relationship between Aggregate Balance and the Deviation of HKD Spot from the Linked Rate (7.8)

Dependent Variable: DLN(7.8-HKSPOT) (difference in natural logarithm of the deviation of HKD spot from the linked rate 7.8)

Independent Variable: DLNAB (difference in natural logarithm of the aggregate balance)

Variable	Coefficient	t-Statistic	Prob.
C	-0.026272	-1.059208	0.2900
DLNAB(5)	-0.494463	-1.635472	0.1025
DLNAB(4)	1.091009	**2.705446**	**0.0070**
DLNAB(3)	0.220778	0.485021	0.6279
DLNAB(2)	0.281708	0.798558	0.4249
DLNAB(1)	0.072165	0.088403	0.9296
DLNAB	-1.282872	**-1.915262**	**0.0560**
DLNAB(-1)	0.260364	0.567656	0.5705
DLNAB(-2)	-0.115456	-0.246128	0.8057
DLNAB(-3)	-0.027772	-0.048878	0.9610
DLNAB(-4)	-0.121165	-0.303537	0.7616
DLNAB(-5)	-0.360333	-0.897376	0.3699
SWITCH	0.028401	1.123544	0.2617
SWITCH*DLNAB(5)	0.374589	1.203391	0.2293
SWITCH*DLNAB(4)	-1.351029	-3.007155	0.0028
SWITCH*DLNAB(3)	-0.593330	-1.113121	0.2661
SWITCH*DLNAB(2)	-0.716301	-1.615707	0.1067
SWITCH*DLNAB(1)	-0.624053	-0.712179	0.4767
SWITCH*DLNAB	0.988153	1.456942	0.1457
SWITCH*DLNAB(-1)	-0.563790	-1.214219	0.2252
SWITCH*DLNAB(-2)	-0.168727	-0.350908	0.7258
SWITCH*DLNAB(-3)	-0.173250	-0.300047	0.7643
SWITCH*DLNAB(-4)	-0.001372	-0.003306	0.9974
SWITCH*DLNAB(-5)	0.339390	0.837000	0.4030
AR(1)	-0.247665	-4.450942	0.0000
AR(2)	-0.136011	-1.931174	0.0540
AR(3)	-0.097148	-1.530500	0.1265
AR(4)	-0.060010	-1.218915	0.2234
AR(5)	0.136989	2.580700	0.0101
R-squared	0.184794		
Adjusted R-squared	0.143667		
F-statistic	4.493209		
Prob(F-statistic)	0.000000		

Table 6. Lead-Lag Relationship between Implied Market Volatility and Realized Market Volatility

Dependent Variable: ABSDLNHSI (absolute value of the difference in natural logarithm of the Hang Seng Index)

Independent Variable: DLNIV (difference in natural logarithm of the implied volatility from Hang Seng Index options)

Variable	Coefficient	t-Statistic	Prob.
C	0.007660	15.51513	0.0000
DLNIV(5)	-0.009348	-1.037945	0.2997
DLNIV(4)	0.002046	0.235194	0.8141
DLNIV(3)	-0.010117	-1.240104	0.2155
DLNIV(2)	-0.008574	-1.082647	0.2794
DLNIV(1)	0.000635	0.080911	0.9355
DLNIV	0.006908	0.555340	0.5789
DLNIV(-1)	0.008519	1.092775	0.2750
DLNIV(-2)	-0.002026	-0.225631	0.8216
DLNIV(-3)	0.006576	0.765717	0.4442
DLNIV(-4)	0.000236	0.025197	0.9799
DLNIV(-5)	0.009515	1.278307	0.2017
DLNIV(-6)	0.001540	0.209048	0.8345
DLNIV(-7)	0.018937	2.253566	**0.0246**
DLNIV(-8)	0.003438	0.431798	0.6661
SWITCH	-0.001372	-2.280035	0.0230
SWITCH*DLNIV(5)	0.018851	1.799812	0.0724
SWITCH*DLNIV(4)	0.002055	0.190050	0.8493
SWITCH*DLNIV(3)	0.018941	1.833577	0.0673
SWITCH*DLNIV(2)	0.016304	1.588178	0.1128
SWITCH*DLNIV(1)	-0.003782	-0.389849	0.6968
SWITCH*DLNIV	0.017195	1.207684	0.2277
SWITCH*DLNIV(-1)	0.000525	0.055986	0.9554
SWITCH*DLNIV(-2)	0.017250	1.643286	0.1009
SWITCH*DLNIV(-3)	0.002402	0.234796	0.8145
SWITCH*DLNIV(-4)	0.007823	0.704744	0.4813
SWITCH*DLNIV(-5)	-0.002111	-0.208645	0.8348
SWITCH*DLNIV(-6)	0.000391	0.042213	0.9663
SWITCH*DLNIV(-7)	-0.008386	-0.833362	0.4050
SWITCH*DLNIV(-8)	0.004937	0.504268	0.6143
AR(1)	-0.047720	-1.275198	0.2028
AR(2)	-0.013171	-0.269288	0.7878
AR(3)	0.059865	1.297021	0.1952
AR(4)	-0.023401	-0.498299	0.6185
AR(5)	0.095523	1.949659	0.0517
R-squared	0.098131		
Adjusted R-squared	0.042682		
F-statistic	1.769738		
Prob(F-statistic)	0.005272		

Table 7. Lead-Lag Relationship between HKD Spot and 6-Month RMB NDF Forward Premium

Dependent Variable: D(7.8-HKSPOT) (difference in the deviation of HKD spot from the linked rate 7.8)

Independent Variable: DLNNDF6MP (difference in natural logarithm of the forward premium of the 6-month RMB NDF)

Variable	Coefficient	t-Statistic	Prob.
C	-0.000136	-1.433044	0.1524
DLNNDF6MP(5)	1.89E-05	2.278454	**0.0231**
DLNNDF6MP(4)	1.23E-05	1.854131	**0.0642**
DLNNDF6MP(3)	7.58E-06	0.993047	0.3211
DLNNDF6MP(2)	-3.00E-06	-0.427877	0.6689
DLNNDF6MP(1)	5.44E-06	0.656909	0.5115
DLNNDF6MP	5.06E-05	4.819683	**0.0000**
DLNNDF6MP(-1)	2.02E-05	2.454819	**0.0144**
DLNNDF6MP(-2)	2.23E-06	0.280241	0.7794
DLNNDF6MP(-3)	2.28E-06	0.323279	0.7466
DLNNDF6MP(-4)	4.05E-06	0.510528	0.6099
DLNNDF6MP(-5)	-9.94E-06	-1.364742	0.1729
SWITCH	0.000151	1.196001	0.2322
SWITCH*DLNNDF6MP(5)	-3.44E-05	-2.680335	**0.0076**
SWITCH*DLNNDF6MP(4)	-1.20E-05	-0.873255	0.3829
SWITCH*DLNNDF6MP(3)	-2.82E-05	-2.140929	**0.0327**
SWITCH*DLNNDF6MP(2)	-4.95E-06	-0.359477	0.7194
SWITCH*DLNNDF6MP(1)	-2.19E-05	-1.562078	0.1188
SWITCH*DLNNDF6MP	-3.77E-05	-2.245403	**0.0251**
SWITCH*DLNNDF6MP(-1)	-3.43E-06	-0.197617	0.8434
SWITCH*DLNNDF6MP(-2)	-2.74E-05	-1.761606	**0.0787**
SWITCH*DLNNDF6MP(-3)	2.73E-06	0.216408	0.8287
SWITCH*DLNNDF6MP(-4)	-1.16E-05	-0.731392	0.4648
SWITCH*DLNNDF6MP(-5)	1.66E-06	0.104062	0.9172
AR(1)	-0.078449	-1.487209	0.1375
AR(2)	-0.070068	-1.435613	0.1517
AR(3)	-0.059589	-0.988967	0.3231
AR(4)	0.006676	0.121563	0.9033
AR(5)	0.020063	0.422294	0.6730
R-squared	0.138502		
Adjusted R-squared	0.095580		
F-statistic	3.226861		
Prob(F-statistic)	0.000000		

Table 8. Lead-Lag Relationship between Six-Month RMB NDF and Three-Month HKD Forward Exchange Rate

Dependent Variable: DHK3MP (difference in three-month HKD forward premium/discount relative to HKD spot)

Independent Variable: **DLNDF6MP** (difference in natural logarithm of the Six-month RMB NDF premium)+

Variable	Coefficient	t-Statistic	Prob.
C	-0.000281	-0.260537	0.7945
DLNNDF6MP(5)	-0.002311	-0.285577	0.7753
DLNNDF6MP(4)	0.012827	1.589024	0.1126
DLNNDF6MP(3)	-0.001109	-0.140657	0.8882
DLNNDF6MP(2)	-0.007170	-0.906404	0.3651
DLNNDF6MP(1)	0.005051	0.575998	0.5648
DLNNDF6MP	0.052514	**4.941335**	**0.0000**
DLNNDF6MP(-1)	0.028854	**2.806349**	**0.0052**
DLNNDF6MP(-2)	0.014375	1.555617	0.1204
DLNNDF6MP(-3)	0.007340	0.901548	0.3677
DLNNDF6MP(-4)	0.013330	1.560223	0.1193
DLNNDF6MP(-5)	0.008869	1.139557	0.2550
SWITCH	0.000801	0.603568	0.5464
SWITCH*DLNNDF6MP(5)	-0.010365	-0.817627	0.4139
SWITCH*DLNNDF6MP(4)	0.000150	0.012377	0.9901
SWITCH*DLNNDF6MP(3)	0.011959	0.968128	0.3334
SWITCH*DLNNDF6MP(2)	0.005740	0.472967	0.6364
SWITCH*DLNNDF6MP(1)	-0.006599	-0.493949	0.6215
SWITCH*DLNNDF6MP	-0.021490	-1.390719	0.1649
SWITCH*DLNNDF6MP(-1)	-0.025004	-1.502673	0.1335
SWITCH*DLNNDF6MP(-2)	-0.017384	-1.197168	0.2317
SWITCH*DLNNDF6MP(-3)	-0.001765	-0.147484	0.8828
SWITCH*DLNNDF6MP(-4)	-0.008777	-0.675544	0.4996
SWITCH*DLNNDF6MP(-5)	-0.024571	-1.761682	0.0787
AR(1)	0.062044	1.155670	0.2483
AR(2)	0.069824	1.096562	0.2733
AR(3)	0.032478	0.621130	0.5348
AR(4)	-0.065098	-1.196488	0.2320
AR(5)	0.116356	2.122980	0.0342
R-squared	0.147368		
Adjusted R-squared	0.104812		
F-statistic	3.462948		
Prob(F-statistic)	0.000000		

Table 9. Lead-Lag Relationship between Six-Month NDF and Hong Kong Market Return

Dependent Variable: DLNHSI (difference in the natural logarithm of the Hang Seng Index)
Independent Variable: DLNDF6MP (difference in natural logarithm of the six-month NDF premium)

Variable	Coefficient	t-Statistic	Prob.
C	0.000649	1.664851	0.0965
DLNNDF6MP(5)	-4.54E-05	-1.473435	0.1412
DLNNDF6MP(4)	-1.30E-05	-0.427494	0.6692
DLNNDF6MP(3)	4.33E-05	1.457282	0.1456
DLNNDF6MP(2)	-2.59E-05	-0.834909	0.4041
DLNNDF6MP(1)	4.38E-05	1.385833	0.1663
DLNNDF6MP	8.95E-05	**2.267213**	**0.0237**
DLNNDF6MP(-1)	4.08E-05	1.432660	0.1525
DLNNDF6MP(-2)	4.82E-05	1.647174	0.1001
DLNNDF6MP(-3)	6.05E-05	**2.151347**	**0.0319**
DLNNDF6MP(-4)	3.53E-05	1.207533	0.2277
DLNNDF6MP(-5)	2.83E-05	**2.431654**	**0.0153**
R-squared	0.037214		
Adjusted R-squared	0.019080		
F-statistic	2.052117		
Prob(F-statistic)	0.022024		

Table 10. Lead-Lag Relationship between Aggregate Balance and Three-Month HIBOR Futures Price

Dependent Variable: DLNAB (difference in natural logarithm of the aggregate balance)

Independent Variable: DLNHIBOR3M (difference in natural logarithm of the three-month LIBOR futures price)

Variable	Coefficient	t-Statistic	Prob.
C	-0.004100	-0.977546	0.3287
DLNHIBOR3M(5)	-2.769135	-0.373491	0.7089
DLNHIBOR3M(4)	3.620800	0.516254	0.6059
DLNHIBOR3M(3)	0.706287	0.128489	0.8978
DLNHIBOR3M(2)	1.980313	0.427440	0.6692
DLNHIBOR3M(1)	-0.444350	-0.079239	0.9369
DLNHIBOR3M	11.54563	0.835791	0.4036
DLNHIBOR3M(-1)	16.08714	1.719961	**0.0860**
DLNHIBOR3M(-2)	13.61967	2.033433	**0.0425**
DLNHIBOR3M(-3)	10.65133	1.694345	0.0908
DLNHIBOR3M(-4)	3.853208	0.504393	0.6142
DLNHIBOR3M(-5)	1.519147	0.248775	0.8036
SWITCH	0.005303	0.811912	0.4172
SWITCH*DLNHIBOR3M(5)	28.15840	2.329934	0.0202
SWITCH*DLNHIBOR3M(4)	-5.535371	-0.397067	0.6915
SWITCH*DLNHIBOR3M(3)	-13.53190	-1.217463	0.2239
SWITCH*DLNHIBOR3M(2)	8.062936	0.736392	0.4618
SWITCH*DLNHIBOR3M(1)	15.78558	1.147605	0.2516
SWITCH*DLNHIBOR3M	-18.73187	-1.142032	0.2539
SWITCH*DLNHIBOR3M(-1)	1.202198	0.060117	0.9521
SWITCH*DLNHIBOR3M(-2)	-2.882709	-0.215576	0.8294
SWITCH*DLNHIBOR3M(-3)	6.960150	0.505559	0.6134
SWITCH*DLNHIBOR3M(-4)	5.437198	0.430913	0.6667
SWITCH*DLNHIBOR3M(-5)	8.509034	0.848020	0.3968
AR(1)	-0.335131	-2.668946	0.0078
AR(2)	-0.060602	-0.792225	0.4286
AR(3)	-0.057707	-1.255942	0.2097
AR(4)	-0.062911	-1.214459	0.2251
AR(5)	-0.044183	-0.813915	0.4160
R-squared	0.163889		
Adjusted R-squared	0.122232		
F-statistic	3.934265		
Prob(F-statistic)	0.000000		

Table 11. Lead-Lag Relationship between Aggregate Balance and Three-Month HKD Forward Premium (or Discount)

Dependent Variable: DLNAB (difference in natural logarithm of the aggregate balance)

Independent Variable: DHK3MP (difference in three-month HKD forward)

Variable	Coefficient	t-Statistic	Prob.
C	-0.009295	-2.533301	0.0116
DHK3MP(5)	0.001375	0.002853	0.9977
DHK3MP(4)	0.105664	0.245001	0.8065
DHK3MP(3)	0.071470	0.175813	0.8605
DHK3MP(2)	0.258693	0.679591	0.4970
DHK3MP(1)	0.242302	0.633172	0.5269
DHK3MP	0.283619	0.524831	0.5999
DHK3MP(-1)	1.015483	**1.743048**	**0.0819**
DHK3MP(-2)	0.581715	1.151095	0.2502
DHK3MP(-3)	0.616824	1.406879	0.1600
DHK3MP(-4)	0.210225	0.519869	0.6034
DHK3MP(-5)	0.405576	1.134199	0.2572
SWITCH	0.003617	0.560803	0.5752
SWITCH*DHK3MP(5)	0.682756	0.668941	0.5038
SWITCH*DHK3MP(4)	0.418875	0.451708	0.6517
SWITCH*DHK3MP(3)	-0.592804	-0.628223	0.5301
SWITCH*DHK3MP(2)	1.644079	1.902476	0.0576
SWITCH*DHK3MP(1)	-0.772553	-0.820247	0.4124
SWITCH*DHK3MP	-0.561054	-0.634039	0.5263
SWITCH*DHK3MP(-1)	0.398909	0.259492	0.7954
SWITCH*DHK3MP(-2)	0.376167	0.248748	0.8036
SWITCH*DHK3MP(-3)	1.063309	0.785752	0.4323
SWITCH*DHK3MP(-4)	-0.710511	-0.470737	0.6380
SWITCH*DHK3MP(-5)	0.233068	0.212496	0.8318
AR(1)	-0.358546	-3.080314	0.0022
AR(2)	-0.082395	-1.098611	0.2724
AR(3)	-0.066161	-1.338044	0.1814
AR(4)	-0.069136	-1.384121	0.1669
AR(5)	-0.000706	-1.028441	0.3042
R-squared	0.168188		
Adjusted R-squared	0.126745		
F-statistic	4.058326		
Prob(F-statistic)	0.000000		

Table 12. Lead-Lag Relationship between Aggregate Balance and Implied Volatility

Dependent Variable: DLNAB (difference in natural logarithm of the aggregate balance)

Independent Variable: DLNIV (difference in natural logarithm of the implied volatility from Hang Seng Index options)

Variable	Coefficient	t-Statistic	Prob.
C	0.015159	0.802322	0.4227
DLNIV(5)	0.074199	0.630782	0.5284
DLNIV(4)	-0.121439	-0.941304	0.3469
DLNIV(3)	-0.127030	-0.685422	0.4933
DLNIV(2)	0.152321	0.777381	0.4372
DLNIV(1)	0.091515	0.499082	0.6179
DLNIV	0.021988	0.133780	0.8936
DLNIV(-1)	-0.105563	-0.669443	0.5035
DLNIV(-2)	-0.030477	-0.285976	0.7750
DLNIV(-3)	-0.031922	-0.392898	0.6945
DLNIV(-4)	-0.009769	-0.195995	0.8447
DLNIV(-5)	0.112614	**2.247935**	**0.0249**
SWITCH	0.017188	0.328247	0.7428
SWITCH*DLNIV(5)	-0.005452	-0.022140	0.9823
SWITCH*DLNIV(4)	0.084184	0.389197	0.6973
SWITCH*DLNIV(3)	0.463774	1.279447	0.2012
SWITCH*DLNIV(2)	-0.351304	-0.932121	0.3517
SWITCH*DLNIV(1)	0.098634	0.181224	0.8563
SWITCH*DLNIV	-0.251133	-0.713266	0.4760
SWITCH*DLNIV(-1)	0.542059	1.390349	0.1649
SWITCH*DLNIV(-2)	-0.613626	-0.740902	0.4590
SWITCH*DLNIV(-3)	-1.044710	-1.003260	0.3161
SWITCH*DLNIV(-4)	1.116110	1.187465	0.2355
SWITCH*DLNIV(-5)	-0.028623	-0.058374	0.9535
AR(1)	-0.701049	-3.484043	0.0005
AR(2)	-0.522441	-2.791984	0.0054
AR(3)	-0.347659	-2.244304	0.0252
AR(4)	-0.227895	-1.825507	0.0684
AR(5)	-0.104497	-1.167286	0.2436
R-squared	0.364495		
Adjusted R-squared	0.334689		
F-statistic	12.22896		
Prob(F-statistic)	0.000000		

Table 13. Granger Causality Tests for Aggregate Balance and Financial Market Variables

	VAR Equations									
	ΔlnAB*		Δln(78-HKspot)		ΔlnHIBOR		ΔlnTurnover		|ΔlnHSI|	
ΔlnAB	1.142	(0.34)	0.767	(0.57)	3.392	(0.01)	0.454	(0.81)	1.452	(0.20)
Δln(78-HKspot)	0.751	(0.59)	10.881	(0.00)	2.680	(0.02)	1.957	(0.08)	1.675	(0.14)
ΔlnHIBOR	0.075	(0.99)	1.229	(0.29)	13.871	(0.00)	0.879	(0.49)	2.041	(0.07)
ΔlnTurnover	0.113	(0.99)	1.361	(0.24)	1.093	(0.36)	10.783	(0.00)	2.212	(0.05)
|ΔlnHSI|	0.158	(0.98)	1.674	(0.14)	2.362	(0.04)	1.526	(0.18)	0.884	(0.49)

* The first equation is given by

$$\Delta \ln AB_t = \alpha_{AB} + \sum_{i=1}^{p} \beta_i \Delta \ln AB_{t-i} + \sum_{i=1}^{p} \delta_i \Delta \ln 78HKspot_{t-i} + \sum_{i=1}^{p} \phi_i \Delta \ln HIBOR_{t-i} + \sum_{i=1}^{p} \delta_i \Delta \ln Turnover_{t-i} + \sum_{i=1}^{p} \delta_i \mid \Delta \ln HSI_{t-i} \mid + u_{AB}$$

The Granger causality F test statistics are reported and the numbers in parentheses are p-values. The lag length p is chosen to be 2 by the Akaike Informatin Criterion. The null hypothesis of Hong Kong spot rate not granger causing changes in aggregate balance is represented by H_0: δ_i=0 for all i. To conclude that Hong Kong spot rate Granger causes changes in aggregate balance, the test must be repeated with the Δln(78-HKspot) equation showing that the hypothesis of aggregrate balance not Granger causing Hong Kong spot rate cannot be rejected.

Table 14. Granger Causality Tests for Aggregate Balance and Derivative Market Variables

	VAR Equations									
	ΔlnAB*		ΔlnHK3MP		ΔlnHIBOR3M		ΔlnIV		ΔlnNDF6MP	
ΔlnAB	0.581	(0.71)	0.862	(0.51)	0.454	(0.81)	0.388	(0.86)	1.483	(0.19)
ΔlnHK3MP	2.993	(0.01)	1.976	(0.08)	3.633	(0.00)	1.350	(0.24)	1.491	(0.19)
ΔlnHIBOR3M	0.796	(0.55)	2.561	(0.03)	2.422	(0.03)	0.871	(0.50)	0.911	(0.47)
ΔlnIV	1.843	(0.10)	1.489	(0.19)	0.322	(0.90)	2.943	(0.01)	1.782	(0.11)
ΔlnNDF6MP	0.765	(0.58)	2.471	(0.03)	0.868	(0.50)	0.711	(0.62)	4.256	(0.00)

* The first equation is given by

$$\Delta \ln AB_t = \alpha_{AB} + \sum_{i=1}^{p} \beta_i \Delta \ln AB_{t-i} + \sum_{i=1}^{p} \delta_i \Delta \ln HK3MP_{t-i} + \sum_{i=1}^{p} \phi_i \Delta \ln HIBOR3M_{t-i} + \sum_{i=1}^{p} \delta_i \Delta \ln IV_{t-i} + \sum_{i=1}^{p} \delta_i \Delta NDF6MP_{t-i} + u_{AB}$$

The Granger causality F test statistics are reported and the numbers in parentheses are p-values. The lag length p is chosen to be 2 by the Akaike Informatin Criterion. The null hypothesis of 3-month Hong Kong forward exchange rate not granger causing changes in aggregate balance is represented by H_0: δ_i=0 for all i. To conclude that 3-month Hong Kong forward exchange rate Granger causes changes in aggregate balance, the test must be repeated with the ΔHK3MP equation showing that the hypothesis of aggregrate balance not Granger causing HK3MP cannot be rejected.

Figure 1. Closing Aggregate Balance (in HKD million) (03/092002 – 31/12/2006)

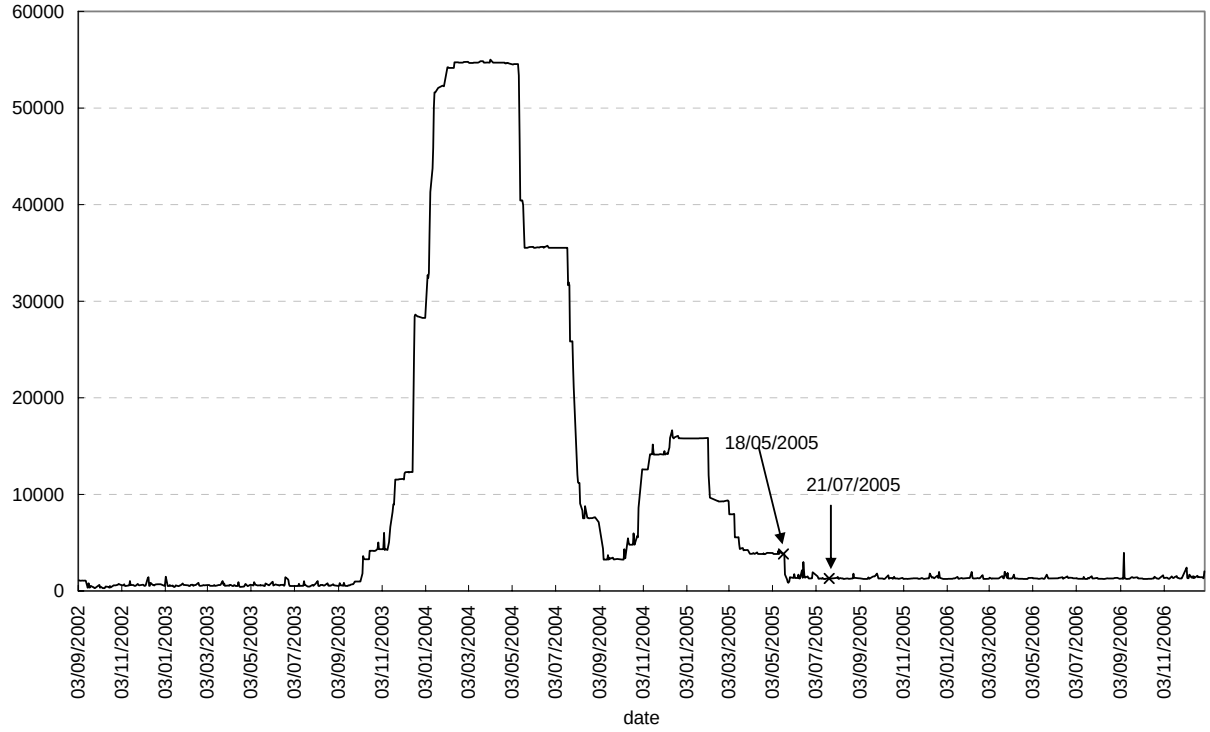

Figure 2. Natural Logarithm of Closing Aggregate Balance (03/09/2002 – 31/12/2006)

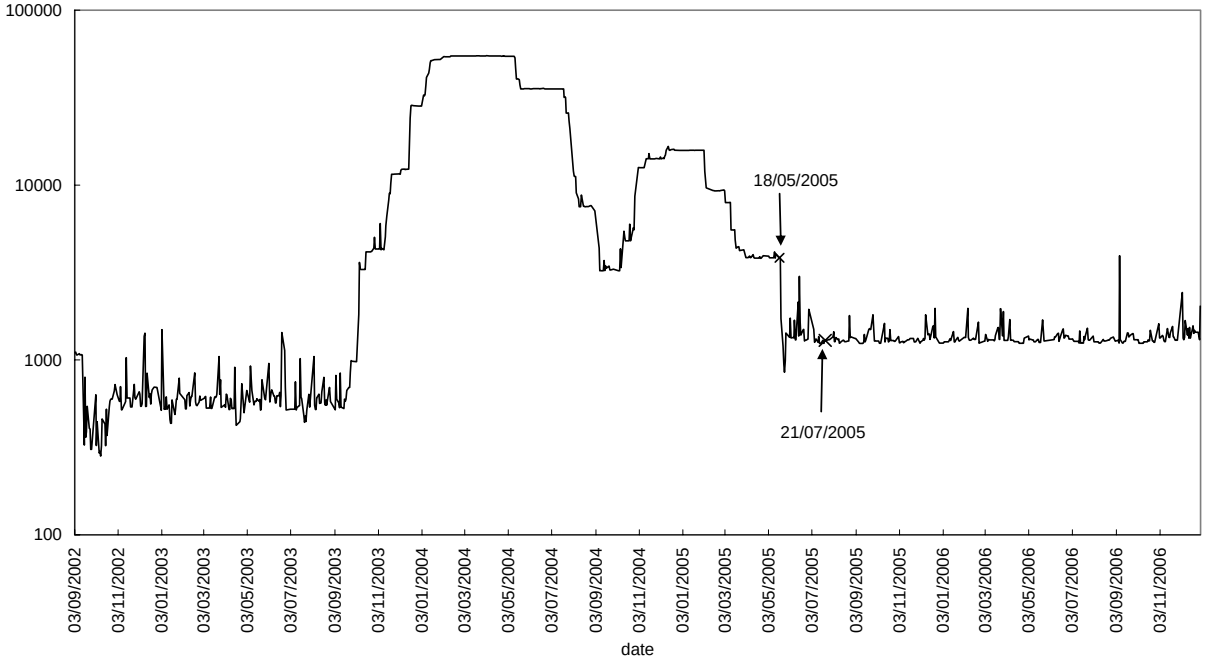

Figure 3. Hang Seng Index and Realized Volatility of HSI (01/01/2004 – 31/12/2006)

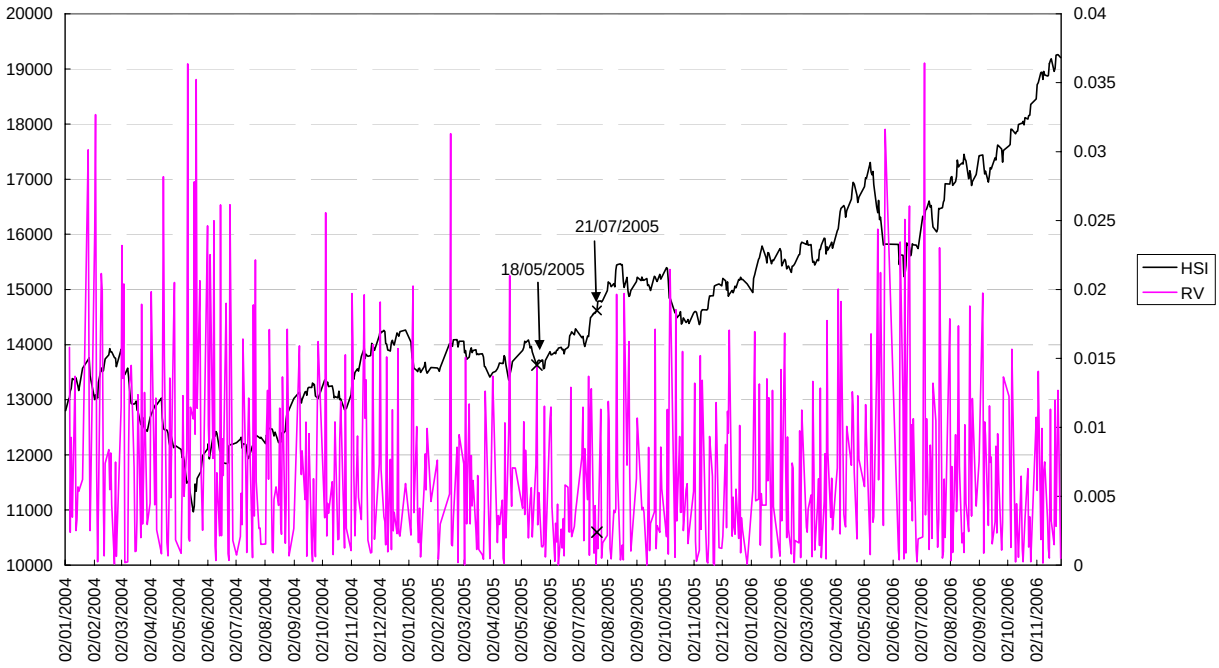

Figure 4. Daily Turnover at the Main Board of the Hong Kong Stock Exchange (01/01/2004 – 31/12/2006)

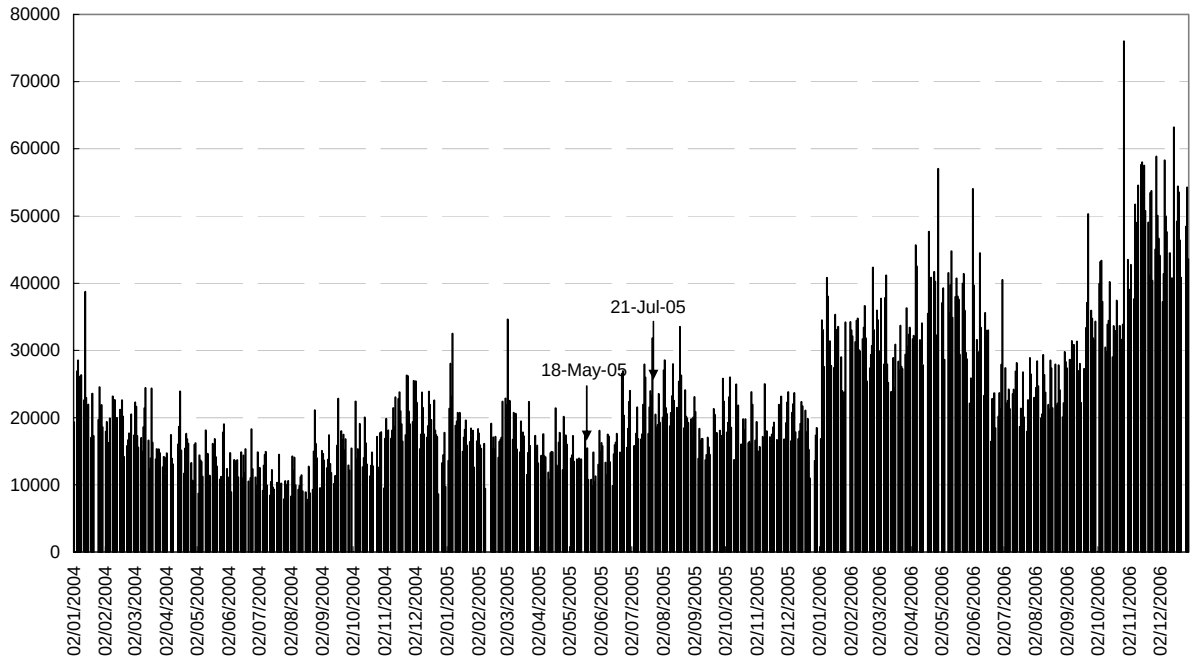

Figure 5. Implied Volatility from Hang Seng Index Options (01/01/2004 – 31/12/2006)

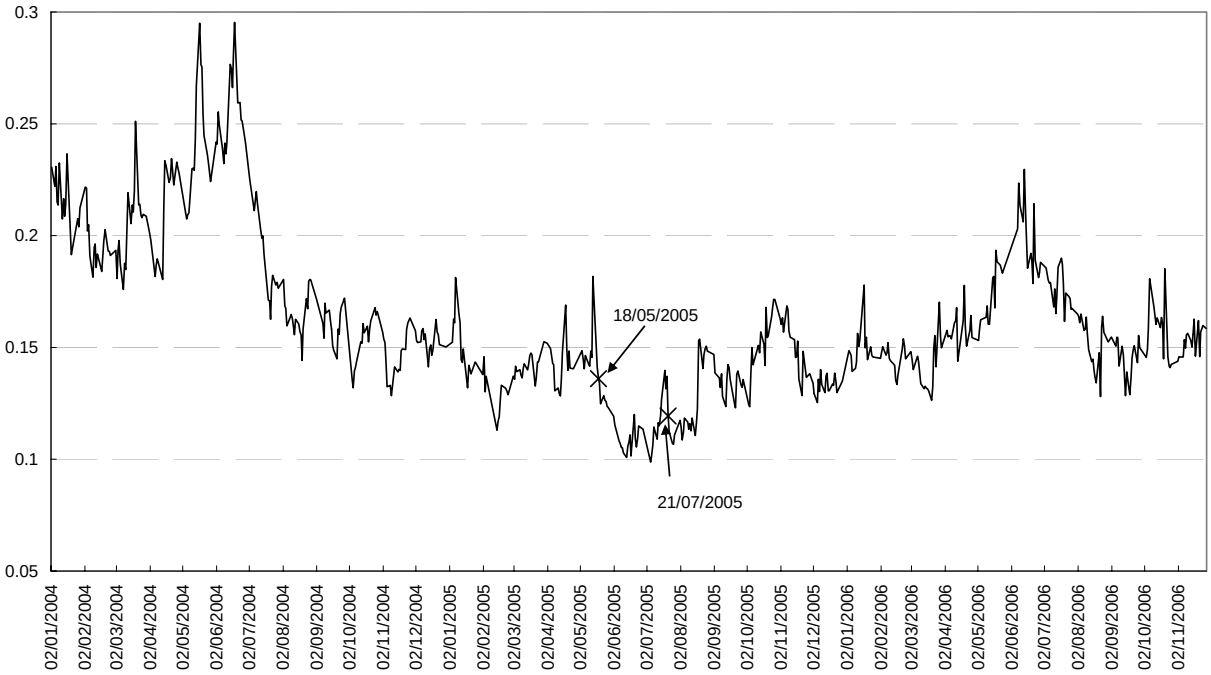

Figure 6. Overnight LIBOR, Overnight HIBOR, and 3-Month HIBOR Futures Price (01/01/2004 – 31/12/2006)

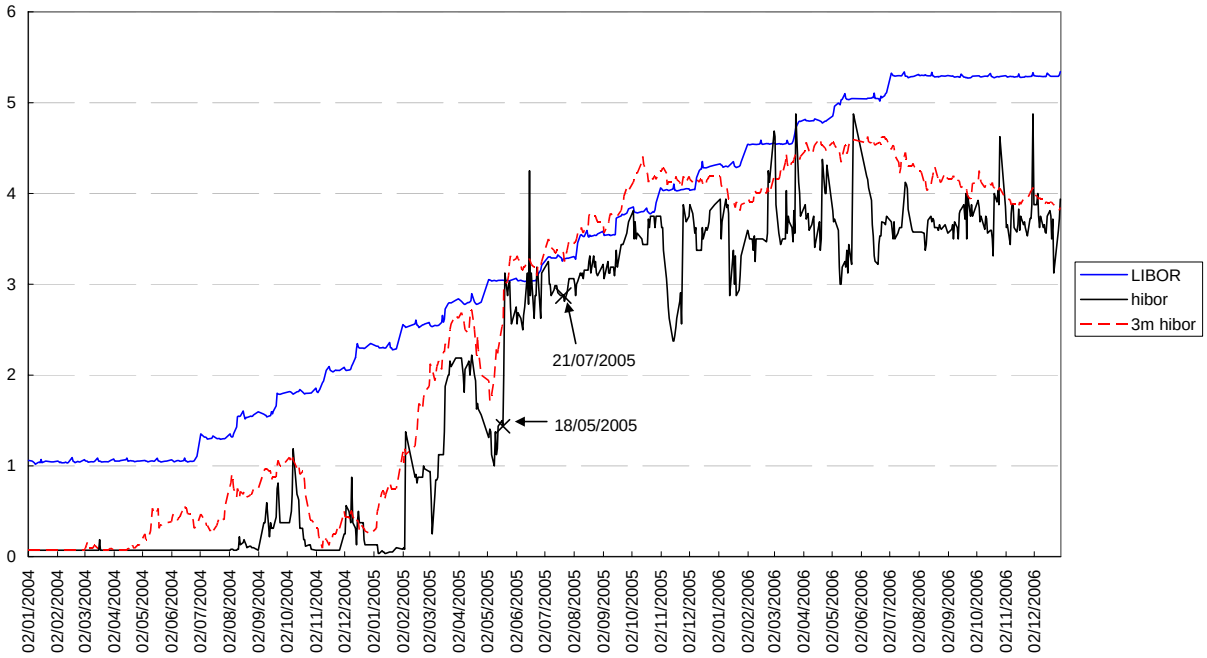

Figure 7. HKD Spot and 3-Month Forward Exchange Rates (per USD) (01/01/2004 – 31/12/2006)

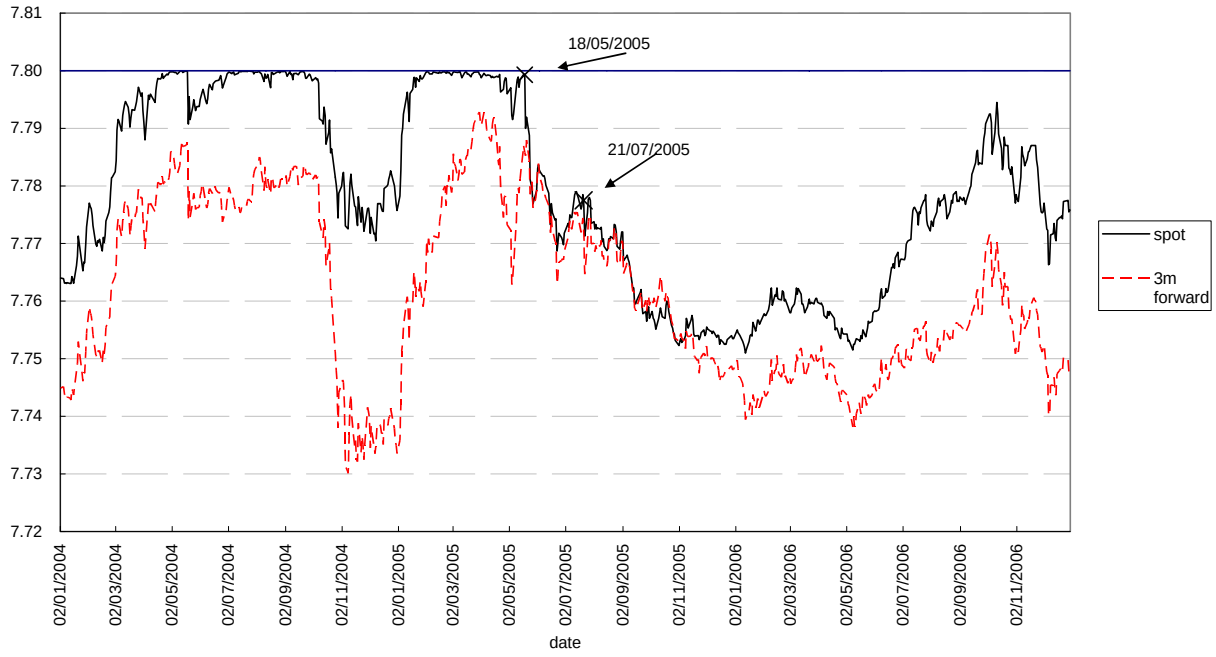

Figure 8. RMB Spot and NDF Prices (per USD) (01/01/2004 – 31/12/2006)