HONG KONG INSTITUTE FOR MONETARY RESEARCH

SWAP CURVE DYNAMICS IN HONG KONG: AN INTERPRETATION

Salih N. Neftci

HKIMR Working Paper No.6/2004

March 2004

Swap Curve Dynamics in Hong Kong: An Interpretation

Salih N. Neftci*

Hong Kong Institute for Monetary Research

and

City University of New York

March 2004

Abstract

This paper investigates the linkage between the USD and HKD swap curves. We argue that these curves contain important information, which is over and above that provided by the sovereign yield curves and the standard measures of market liquidity, Libor-type interest rates. Our work indicates that using sovereign yield curves and concentrating only on the risk premia associated with the breakdown of the currency peg is not sufficient for policy making in Hong Kong. Swap spreads and swap curves should be carefully monitored to evaluate economy wide risks and to conduct macroeconomic policy.

JEL Classification: G15, E44

* Ph.D. Program in Economics, The Graduate Center, City University of New York, 365 Fifth Avenue, New York, NY 10016. E-mail: sneftci@gc.cuny.edu.

1. Introduction

Swap spreads consist of information that is fundamentally different than what one can obtain from sovereign yield curves. This information should constantly be monitored by policy makers; including central banks. In this paper we provide evidence that supports this claim by studying the USD and HKD swap markets. We try to identify and then interpret the new information contained in the Hong Kong swap curve. Important policy implications are then discussed.

The swap curve has become the primary benchmark for assessing interest rate movements and should be at the center stage of risk management and risk monitoring activities. Yet, swap curve dynamics has not received much attention from researchers dealing with macroeconomic policy. Important information that may be contained in swap curve dynamics is often not taken into account when formulating monetary policy. Investigating these issues in the Hong Kong economy is particularly important given some special aspects of Hong Kong financial markets.

A fundamental aspect of the Hong Kong economy is the so-called “peg” and the risks associated with it. The Hong Kong dollar (HKD) is pegged to the U.S. dollar (USD) and the Hong Kong Monetary Authority (HKMA) acts as the currency board that preserves this peg. This constitutes the major feature of Hong Kong financial markets. The HKMA issues Exchange Fund Bills and Notes (EFBN) that are “direct, unsecured obligations of the Hong Kong SAR Government for the account of Exchange Fund.” The EFBNs can be used for trading, investment and hedging instruments. For example, those institutions that maintain Hong Kong dollar clearing accounts with the HKMA can use their EFBN holdings to borrow O/N dollars from the discount window. The HKMA has taken the necessary steps to create an active primary and secondary market which led to the creation of a *sovereign* benchmark yield curve for up to 10 years. This has facilitated the creation of a benchmark swap curve for the same maturity, although the swap curve contains significant additional information concerning the Hong Kong economy.

There are several interesting issues that emerge in this environment. Market professionals and economists attribute the difference between the USD and Hong Kong *sovereign curves* to the existence of the “peg”. However, the differences between the *swap curves* of the two currencies may be due to several other important factors that may be as important as the peg and may have relevance for monetary policy. The rich data set concerning swap curves permits a detailed study of these issues and this paper is an attempt in that direction.

The paper is organized as follows. In the next section we provide a brief discussion of the main parameters of Hong Kong financial markets. Then in the third section we discuss the relevance of swap curves in tracking and monitoring term structure related risks. Section 4 provides a theoretical setting for interpreting swap rates and the related floating rates. We obtain some pricing formulas and show the important relationship between swap rates and the “aggregate credit risk” of a private economy. Section 5 deals with the data set and the empirical evidence. Finally, Section 6 summarizes our main findings and the relevant policy implications.

2. Background for Hong Kong Markets

Hong Kong has a currency board regime administered by the HKMA, which was set up during the year 1993. The HKMA manages actively Hong Kong's official reserves which are called the "Exchange Fund". The composition of the assets of the HKMA can be altered at the discretion of Exchange Fund management. The assets of the Exchange Fund are substantial.[1] The possibility of entering the markets to change the composition of such a portfolio may have a significant impact on the underlying rates and returns. This makes the Exchange Fund a major player in world financial markets.

2.1. Debt securities

One way to visualize the swap curve is to begin with a benchmark sovereign curve and then add to this a proper swap spread which results from a liquid interest rate swap market. In the case of Hong Kong a benchmark sovereign curve can be obtained from the secondary market trading of the Exchange Fund Bills and Notes (EFBN). Exchange Fund Bills have short maturities of 1 week, 91, 182 and 364 days and are auctioned in the form of public tender on a regular basis. They are quoted on an ACT/360 basis. The Exchange Fund notes have longer maturities of 2, 3, 4, 5, 7 and 10 years and are quoted on an ACT/365 basis. The HKMA has established a set of official fixings for these securities.[2]

These debt instruments are traded in a two-tier dealership scheme, where the HKMA appoints a number of Recognized Dealers that deal in the primary market and Market Markers that deal in the secondary market. These institutions are committed in supporting a liquid market in these securities.

These debt instruments can be used as collateral against overnight (O/N) borrowing, as margin collateral in the Hong Kong Futures Exchange for trading stock index futures and options. More importantly for our purposes, these securities can be used as collateral in Hong Kong dollar repo transactions.[3]

The Exchange Fund Bills and Notes (EFBN) form part of the monetary base of Hong Kong. The other important elements of the monetary base are the certificates of indebtedness, which are the backing for banknotes and coins and the aggregate balance of the banking system maintained at the HKMA for the purpose of clearing and settlements between banks and the HKMA. The currency board system in place requires that the foreign assets of the HKMA be greater or equal to this monetary base. The HKMA does not issue banknotes. The Hong Kong and Shanghai Banking corporation, Standard Chartered Bank and the Bank of China (Hong Kong) issue banknotes on behalf of the HKMA. When these banks issue banknotes they deliver the required amount of USD to obtain the Certificates of Indebtedness.

---

1 The size of the balance sheet of the HKMA was over HK$961 billion (over US$100 billion) at the start of 2003. More than 90% of the assets were denominated in foreign currencies.

2 The fixings are calculated using the arithmetic mean of 8 mid-quotes from the market at 11:00 am; after excluding the two highest and two lowest quotes.

3 In addition to the Exchange Fund Bills and Notes, the HKMA extended its note issuance program to include debt securities issued by agencies such as Mass Transit Railway Corporation, Airport Authority, and the Kowloon-Canton Railway corporation. These securities are labelled as "Specified Instruments" and are fungible with Exchange Fund securities. They can also be used as collateral in discount window borrowing. The other important debt issuing agency is the Hong Kong Mortgage Corporation (HKMC) which is owned by the Exchange Fund, issues debt securities and purchases mortgages. During the year 2002 the HKMC issued HK$15 billion (US$1.9 billion) of new debt and had a mortgage portfolio of HK$28 billion.

2.2. Swap markets

Hong Kong has a relatively liquid swap market. The floating rate in these swaps is 3-month Hibor (Hong Kong Interbank Offered Rate)[4] and has an ACT/365 day count basis. The fixed leg of swaps is also quoted ACT/365 and on a *quarterly* basis per year. Active tenors of the swap market would be 2 to 10 years and trading sizes would be HK$200 million. A typical bid-ask spread would be 10bp. The daily turnover would be around HK$9 billion and is significantly higher than that of HKS2.5 billion for the EFBNs.

According to market practitioners the HK swap curve is priced off the USD swap curve.[5] Market practitioners think that the differences arise mostly because of the risks associated with the currency peg. This, in fact, is one important issue in our study. In this paper we claim that there may be significant effects other than risks associated in the currency peg that is involved in the USD-HKD swap differences.

Players in international markets express views on the Hong Kong peg through positions taken either with currency forwards; short end of the swap curves or with the long end of the swap curves. Although similar positions can be put in place using the EFBN and US Treasuries, market players do not prefer this approach. This may be due to balance sheet, funding and repoing costs that will be associated with dealing with EFBNs.

One of the major players in the swap market is the HKMA. With the yield curve being positively sloped, the HKMA has thus far preferred to swap the 10 year EFBN proceeds into floating rate funds. This means sudden demand for receiving fixed after an issue of a 10 year EFBN, which makes the 10 year swap rates go down and trade "tighter" for a while. This point is another issue that we investigate in this paper. It is interesting to see which counter-parties take the other side of such deals and what their objectives are. An analysis of these points may uncover some unseen risks in banking portfolios.

2.3. The Repo market

Unlike the USD market, there is no OTC repo market in Hong Kong. Short-selling of EFBNs is limited to market makers. A player who shorts an EFBN has to cover this short position by entering into a one-day repo agreement with the HKMA. This could be done by exchanging the short security against a proper amount of other similar securities.

This structure of Hong Kong repo markets sets them apart from US dollar repos, which have a fundamentally different role to play in the US markets. Traders can use US dollar repo markets to fund their fixed income portfolios. Hong Kong repo markets' primary role is in guaranteeing the covering of short positions, in particular EFBNs. The structure of Hong Kong markets eliminate the notion of *special repo*. A short position in *any* EFBN can be covered overnight using this market. This eliminates many of the repo strategies that play an important role in European and US markets. In some sense, it "separates" the sovereign curve more from the Hibor and swap curves.

---

4 The rate of interest offered on Hong Kong dollar loans by banks in the interbank market for a specified period ranging from overnight to one year.

5 See the very useful Deutsche Bank report on Hong Kong fixed income markets mentioned among the references.

3. Swap curves are the "right" Benchmarks

Analysis of macroeconomic policy is still done using the sovereign yield curve, reflecting the tradition of standard deterministic macroeconomic models. In the US the Treasury yield curve is used. In Hong Kong the benchmark yield curve is obtained from the EFBNs. Yet, in economies heavily dominated by private sector activities, sovereign yield curves have limited use. Swap markets provide benchmark yield curves that are much more appropriate for macroeconomic policy than the sovereign yield curves. There are several reasons for this.

We start with technical points. First, swaps are much more liquid than the sovereign bonds, even in Hong Kong markets, and at any time during the day one can obtain constant maturity par swap yields. Bond maturities on the other hand change as time passes and this leads to complicated numerical procedures to extract from observed bond trading data, the constant maturity yields that are needed for the curve. Second, bond trading data are not as homogenous as those from swap trading. There are repo specials and this may lead to prices that are out of line with the yield curve at any instant. Cleaning such "special" trades from observed data may not be possible. These are two technical reasons why swap yield curves can give more reliable estimates of the state of the true yield curve from a macro perspective. Third, bonds often contain implicit options that will distort their pricing. Decision makers need to calculate and then look at stripped yields.

However, substantial reasons for using swap curves abound. In a private sector dominated economy the government's borrowing cost often has little relevance to macroeconomists. The more relevant cost of funds is what is paid by the aggregate private sector, after *eliminating the idiosyncratic default risk premia*. The swap curve reflects exactly this notion.

The swap spread, being the difference between the swap rate and the comparable maturity sovereign rate, measures some important variables that are critical for macroeconomists. First of all, swap spreads reflect an overall cost of *available liquidity* for the private sector companies, while sovereign yield curves contain imperfect information on this point. The slope of the sovereign yield curve is sometimes taken as a proxy for available liquidity. The higher the (positive) slope, the lower short term interest rates are compared to long rates. This may be contributed to the Central Bank's stance on easing the liquidity window. But, it may also be due to several other economic phenomena. One example is varying inflationary expectations or, more importantly, views on volatility.

It turns out that convexity trades may, depending on the level of volatility, influence the slope of the sovereign yield curve. For example, everything else being the same, an increase in long term interest rate volatility will *decrease* long term yields and this would lower the slope of the yield curve. Such an event does not mean that market *liquidity* has increased, yet using the slope of the yield curve would imply exactly this. Use of the swap spread as a measure of macroeconomic liquidity will avoid such problems.

In addition, when evaluating firm-wide credit risks, market practice is to look at spread to swaps rather than spread to Treasury benchmark curves. This eliminates anomalies due to Treasury actions. But such practice is also intended to partial out the effect of swap spreads which contains an economy-wide credit spread of the private sector. This way market professionals are able to isolate the idiosyncratic credit risk that is particular to the individual firm's actions. But this implies, at the same time, that the swap spread contains an "aggregate credit risk" that is priced in. For macroeconomic policy makers the relevant risk is this aggregate credit risk, not the idiosyncratic credit risks that will be averaged out in an aggregate setting.

3.1. The role played by liquidity

There are two different notions of liquidity that we need to deal with within this context. They are both critical from the point of view of financial markets. The first is the notion of liquidity used in the previous section. Central banks provide liquidity by means of adjusting the *money supply*. One measure of this liquidity is the relative cost of securing short-dated funds and this is what we discussed in the previous section. There is no doubt that this notion of liquidity, which, in a sense measures the stance of monetary policy, is important for financial markets. Economists often use the slope of the sovereign yield curve as a proxy for this notion of liquidity.

For financial market participants, the *liquidity* of the underlying security is also important. This notion of liquidity refers to the ease of buying and selling relatively large amounts of assets in ways that do not affect the market prices, and it measures the ease of transacting large deals. To the extent the market goes through periods of illiquidity, the absorption of large deals will take time and this would introduce some further volatility into the swap rates. There is no question that this notion of liquidity is also important for securing a smooth functioning of the financial markets.

4. Swap Engineering

We now briefly discuss the financial engineering of swaps to obtain the necessary pricing equations. We focus on plain vanilla *interest rate* swaps.

Suppose that the interest rate swap is initiated at date t_o. A counter-party makes *n* fixed payments and will receive n floating payments at dates $t_1, \ldots, t_n$ in the same currency. The dates $t_1, \ldots, t_n$ are *settlement* dates and the $t_0, \ldots, t_{n-1}$ are *reset* dates. The latter are dates on which the relevant Libor (Hibor) rate will be redetermined.

The swap notional amount is denoted as N and let the floating rate tenor be represented by δ. Assume that the floating rate is 3-month Libor (Hibor), so that δ is 1/4. The fixed swap rate will be given as s_{t_o} and the Libor rates will be $\{L_{t_o}, \ldots, L_{t_{n-1}}\}$, respectively. The *swap spread*, w_{t_o} , will be the difference between s_{t_o} and the yield on the sovereign bond with the same maturity. This sovereign yield is denoted by y_{t_o}.[6] That is,

$$w_{t_o} = s_{t_o} - y_{t_o} \tag{1}$$

[6] This could be any interest rate accepted as a benchmark by the market.

Such a swap can be reverse-engineered in different ways.

1. One can first decompose the swap into two streams of cash flows, one representing a floating stream of payments (receipts), the other a fixed stream. If this is done, then each stream can be interpreted as representing various types of bonds.

2. Second, one can decompose the swap according to settlement dates, slicing it into n cash exchanges during n time periods. If this is done, then each cash exchange can be interpreted as a Forward Rate Agreement, or FRA-in-arrears, with a special characteristic that the FRA rate is constant across different settlement dates.

Both approaches above will generate the same swap pricing formula. We choose to use the second approach because it is easier and it displays some interesting aspects of swap rates better. At time $t_i + \delta$, Forward Rate Agreement (FRA) counterparties will exchange the following cash flow:

$$[F(t_o, t_i) - L_{t_i}]\delta N \tag{2}$$

where N is the notional amount and the $F(t_o, t_i)$ is the FRA rate determined at time to. Note that this amounts to exchanging the fixed payment $F(t_o, t_i)\delta N$ against the floating payment $L_{t_i}\delta N$.

Now consider the relationship between the fixed swap rate s_{t_o} and the FRA rate. We see that the FRA rate $F(t_o, t_i)$ is determined independently from the s_{t_o}, either by supply and demand or by pricing through money markets. In general;

$$F(t_o, t_i) \neq s_{t_o} \tag{3}$$

This means that if we buy the ith swap cash flow and sell the cash flow implied by the ith FRA, the Libor (Hibor) payments will cancel out, but the fixed payments won't since they are *not* equal. As a result, this portfolio will end up with a *known* negative or positive net cash flow at time t_{i+1}. Since this cash flow is known exactly at time t_o; and there is no credit risk, this portfolio *must* have a known present value at time t_o. This present value will equal:

$$B(t_o, t_{i+1})[F(t_o, t_i) - s_{t_o}]\delta N \tag{4}$$

where the $B(t_o, t_{i+1})$ is the current value of a default-free zero coupon bond that matures at time t_{i+1}, with par value of 1 HK dollar. This expression tells us that the present value will be positive or negative depending on whether $F(t_o, t_1) > s_{t_o}$ or not. Of course, this should be true for all the elements of the swap individually. Also swap cash flows *altogether* need to have zero present value. This yields an important pricing relationship:

$$\sum_{i=0}^{n} B(t_o, t_{i+1})[F(t_o, t_i) - s_{t_o}]\delta N = 0 \tag{5}$$

From here, rearranging the equation we could get a formula that ties the swap rate to the forward rates:

$$s_{t_o} = \frac{\sum_{i=1}^{n} B(t_o, t_i) F(t_o, t_i)}{\sum_{j=1}^{n} B(t_o, t_j)} \tag{6}$$

This formula is important because it shows a relationship between the floating forward Libor (Hibor) payments and the relevant swap rates.

4.1. Interpreting Hibor and swap rate interactions

A swap involves exchanges of cash flows. But cash flows are generated by assets, liabilities, and other commitments. This means that swaps are simply a standardized, liquid, and cost-effective alternative to trading cash assets. Instead of trading the cash asset or liability, one can simply trade the cash flows generated by it. Because swaps in general have zero value at the time of conception and are very liquid, this key feature indeed makes them cost-effective alternatives. Hence their wide use in position-taking, hedging, and risk management.

Formula (6) expresses the swap rate in terms of the forward rates and can be rewritten as follows:

$$s_{t_o} = \sum_{i=1}^{n} \omega_{t_o}^{i} F(t_o, t_i) \tag{7}$$

where the $\omega_{t_o}^{i} s$ are weights that add up to one, and they depend on the zero coupon discount bond prices:

$$\omega_{t_o}^{i} = \frac{B(t_o, t_i)}{\sum_{j=1}^{n} B(t_o, t_j)} \tag{8}$$

As time passes these discounts will change and this will modify the weights $\omega_{t_o}^{i}$

First consider the stability of the weights $\omega_{t_o}^{i}$. Parallel shifts in the yield curve will have relatively little impact on these weights. Significant changes in the slope of the yield curve can on the other hand modify the $\omega_{t_o}^{i}$ significantly. However, yield curve inverts rarely and this means that we can analyze the swap rate – forward rate relationship by acting as if these weights are relatively constant.

Under these assumptions we may interpret the swap rate as some type of *weighted average of forward rates*. Since forward rates can be regarded as (possibly biased) expectations of future Hibor rates that will be observed during respective swap settlement periods, the swap rate will be taken as a weighted average of the forward Hibor rates.[7]

Using equation (7) we can elaborate more on the Hibor-swap rate relationship. Hibor is an average of the borrowing rates for 20 Hong Kong banks. It is also an interbank rate and applies to non-secured loans. The weighted average of the credit rating of the banks, from which the Hibor fixing is determined, is likely to be around A+ or AA-. Thus Hibor rates L_{t+i} *will* incorporate some credit risk.

---

7 However, these weights are not equal. In fact the $\omega_{t_o}^{i}$ will be declining, making the near Hibor rates play a more important part in determining the swap rates than the distant Hibor rates.

Suppose R_{t_i} is the *term repo rate* in a *privately arranged* repo deal struck with an AAA-rated repo dealer with zero haircut and against general collateral made of EFBNs.[8] Then the Hibor and repo rates will be related according to:

$$L_{t_i} = R_{t_i} + c_{t_i} \tag{9}$$

where c_{t_i} is the credit risk spread between *average* A+ credits and sovereign credits.[9]

Using this relation we can rewrite the swap rate as:

$$s_{t_o} = \sum_{i=1}^{n} \omega_{t_o}^{i} \left[E_{t_o}^{\tilde{P}} \left[R_{t_i} \right] + E_{t_o}^{\tilde{P}} \left[c_{t_i} \right] \right] \tag{10}$$

where $\tilde{P}$ is an appropriate martingale probability. The first term in brackets is an average of expected repo rates and the second term is an average of expected future A+ credit spread.

All this means that the Hong Kong swap rate is expected to incorporate the following effects:

- The Hong Kong dollar is pegged to the USD and, hence, the USD Libor should have some significant effect on the Hibor. This effect will be independent of the average A+ credit risk premia that will move according to local variables in the two economies. Thus the correct way to model the relationship is to use the repo rates:

  $$R_{t_i} = R_{t_i}^{usd} + p_{t_i} \tag{11}$$

  where the $R_{t_i}^{usd}$ is the USD term repo rate for the same period and p_{t_i} is the risk premium due to breakdown possibility of the currency peg. Under this characterization the p_{t_i} will depend only on the currency peg and will be independent of any credit risk related factors.

- The Hong Kong swap rate is an average of expected Hibor rates and hence depends on the changes in the average credit risk for A+ rated credits. The movement of the average credit risk in the Hong Kong should be independent of any movement in the USD sovereign curve.

- Hibor is a measure of short term liquidity and in reality one would expect a *liquidity premium* to be priced in the forward rates. This liquidity risk should affect the swap rates as well.

---

8 In Hong Kong such OTC repo markets do not exist. Yet, such a deal can always be structured.

9 Note that accordingly a *typical* A+ credit is still going to command a positive credit default swap (CDS) rate, even though the theoretical CDS rate (cds_{t_i}) for the *same n* periods and for the same *average* A+ credits will on the other hand be: cds_{t_i} = 0. This should normally be the case since the CDS rate is quoted as a spread to the relevant swap rate. Yet, in reality, CDS contracts offer practicality, deliver options and liquidity to clients, and the CDS rates of individual banks will all be positive.

- Finally, to the extent that there exists a significant *counterparty risk* in swap contracts, the swap rate would also depend on the changes in this swap counterparty risk. This clearly hinges upon whether the swap contract under consideration provides collateralization of positive or negative swap values during the maturity of the contract. Swap spread dynamics should provide information concerning the aggregate counterparty risks as well.

These relationships suggest the following hypotheses that can be tested using the available swap data for USD and HKD:

First, we expect Hibor to be significant in explaining Hong Kong swap rates. To the extent that Hibor rates are measures of HKD liquidity, they will play a role in determining Hong Kong swap rates.

Second, we expect the US treasury curve to play a significant role in determining the Hong Kong swap rates. Both of these hypotheses are based on the consideration of the existence of the Hong Kong currency peg.

Third, we expect the USD swap spreads not to determine the Hong Kong swap rates over and above the USD treasury curve and the USD Libor. This hypothesis is justified by the fact that, once liquidity and the peg effects are taken out, the USD swap spreads will essentially represent the average credit spread of the US economy and will be linked to the USD specific macroeconomic factors that affect liquidity. These effects should not influence Hong Kong swap rates over and above the Treasury curve and USD Libor.

Finally, as the last hypothesis to be tested, we are interested in detecting if the Hong Kong swap curve has a component that is exogenous to the USD related variables. In other words, credit spread changes of Hong Kong companies, local macroeconomic conditions may affect the Hong Kong dollar swap rates over and above the effect of USD related variables, and we would like to know if this is indeed the case.

5. Empirical Evidence

5.1. Data

We investigate the above postulated hypotheses by looking at the data on (a) Libor, Hibor rates, (b) US Treasury curve, (c) US dollar swap spreads, and (d) Hong Kong dollar swap curve. The empirical work uses five maturities for the relevant curves, namely 3, 4, 5, 7 and 10 year tenors. The USD Libor and the Hibor have a 3-month tenor. The data are daily and cover the period of 1997 to 2003. For USD swap spreads we use semi-annual 360 day rates. Hong Kong swap rates are quoted on a quarterly 365-day basis and these differences require a small adjustment. The data are collected from Bloomberg.

5.2. Preliminary analysis of the sample data

Figure 1 displays the US dollar and the Hong Kong dollar swap curves over the sample period. Overall we see that the time series behavior of the two curves is quite similar except for the period of the Asian financial crisis, when the Hong Kong swap rates spike for a period of about 290 trading days. Starting from the third week of October 1997 when the Hong Kong dollar came under speculative attack, the huge spike subsides by the end of 1998. After that period Hong Kong swap rates continue to be in sync with the USD swap rates.

The swap term structure for Hong Kong and the US during the same sample period is constructed in Figure 2. We see that the Hong Kong swap rates are, for this particular sample period, on average 110 basis points higher than the USD swap rates at the 10 year maturity. It decreases to about 75 basis points at the 1 year maturity. This difference can be found as “too large” by market practitioners who are used to swap rate spreads of around 40-50bp for the USD and HKD. But, it must be remembered that our sample does contain the period of the Asian financial crisis and for about 200 days the USD and HKD swap spreads diverged by more than 300 basis points. Excluding this period leaves a spread of around 40-45bp. However, it may not be appropriate to exclude the Asian crisis since it is a period of legitimate turbulence that has great relevance for monitoring the risks associated with the currency peg.

Figure 3 shows the time series on the difference between the USD and HKD swap rates at 5-year maturity. Our final preliminary investigation of the data concerns the second half of this figure. We see from this plot that the spread at the 5-year maturity between the USD and HKD swap rates has a positive trend. This is supported by a simple regression. Figure 4 provides the estimate of the simple regression on the subsample:

$$s_t^{hkd} - s_t^{usd} = \alpha + \beta t + \epsilon_t \tag{12}$$

Here the s_t^{hkd} and s_t^{usd} are the 5-year USD and HKD swap rates; *t* is the time trend. Results indicate that there is indeed a significant positive trend in this swap differential over the subsample period between 2000 and 2003.

This is occurring during a period of deflationary pressures and relative calm in Hong Kong currency markets. The deflationary pressures have negative effects on default risk and the associated credit risk premia. The fact that the swap differentials are on the increase during a period where no questions were raised about the peg is a preliminary indication that swap spreads provide information on aggregate credit risks as well as on the peg breakdown risk.

5.3. Joint time series dynamics

To investigate the complex dynamics that exists between US Treasury curve, USD swap spreads, HKD swap curve and the Hibor, Libor rates, a linear Vector Autoregressive system is adopted. We let the $Y_t^{usd}, sw_t^{usd}, s_t^{hkd}$ represent respectively the time-*t vectors* on the data concerning the US treasury curve, USD swap spreads, and the Hong Kong swap rates. Each vector is 1 by 5. Let L_t^{hkd}, L_t^{usd} be the time *t* Hibor and USD Libor rates respectively.

Then we can consider the following block linear system:

$$\begin{pmatrix} L_t^{hkd} \\ L_t^{usd} \\ Y_t^{usd} \\ sw_t^{usd} \\ s_t^{hkd} \end{pmatrix} = \begin{pmatrix} A_{11} & A_{12} & A_{13} & A_{14} & A_{15} \\ A_{21} & A_{22} & A_{23} & A_{24} & A_{25} \\ A_{31} & A_{32} & A_{33} & A_{34} & A_{35} \\ A_{41} & A_{42} & A_{43} & A_{44} & A_{45} \\ A_{51} & A_{52} & A_{53} & A_{54} & A_{55} \end{pmatrix} \begin{pmatrix} L_t^{hkd} \\ L_t^{usd} \\ Y_t^{usd} \\ sw_t^{usd} \\ s_t^{hkd} \end{pmatrix} + \begin{pmatrix} \epsilon_{1t} \\ \epsilon_{2t} \\ \epsilon_{3t} \\ \epsilon_{4t} \\ \epsilon_{5t} \end{pmatrix} \tag{13}$$

In this model the A_{1j}, j = 1, ..5, is a 1 by 5 row vector of coefficients made of *lag operators*.[10] Similarly for the A_{2j} to A_{5j}, j = 1, ..5. These coefficients show how the variable under consideration affects the Libor rates. The coefficients of interest to us are the A_{5j}, j = 1,.., 5. These are 5 by 5 matrices of coefficients showing how the underlying variables affect the Hong Kong swap rates.

In particular, the $A_{5,1}$ is a vector showing the impact of Hibor on the Hong Kong swap curve. The $A_{5,2}$ is a vector of coefficients showing how USD Libor affects the Hong Kong swap curve. The other three vectors of coefficients can be interpreted as follows. The $A_{5,3}$ describes the effect of the US treasury curve on the Hong Kong swap curve. Similarly the $A_{5,4}$ indicates the effect of the US swap spreads on the Hong Kong swap curve and finally, the $A_{5,5}$ tells us how the past history of Hong Kong swap rates influences itself. The hypotheses discussed in this paper suggest that:

- Hypothesis 1. The peg is relevant in determining the Hong Kong swap rates, as expected by everybody, the US treasury curve will be significant and that:

$$A_{5,3} \neq 0 \tag{14}$$

- Hypothesis 2. The USD swap spreads do not affect Hong Kong swap rates over and above USD sovereign curve, we would have:

$$A_{5,4} = 0 \tag{15}$$

- Hypothesis 3. Hong Kong swap rates contain useful information that is independent of the USD Treasury or swap curves, then:

$$A_{5,5} \neq 0 \tag{16}$$

Tables 1 to 3 summarize the results of testing these hypotheses using the model shown in (13) along with the data described above. In the version of the model reported here we used 5 lags. The use of 10 or 15 lags does not change the general pattern of the results, while consuming a lot more degrees of freedom.

With regard to the first hypothesis, consider the F-tests reported in Table 1. We see that these tests are *very* significant, in other words; the US treasury curve has a strong impact on the time series dynamics of Hong Kong swap rates. Given the existence of the currency peg this is not a very surprising result.

---

10 The current lag has zero coefficient.

The more interesting result emerges from hypothesis 2. Table 2 reports the sum of squares of restricted and unrestricted regressions that test the hypothesis that $A_{5,4}$ = 0. We see that according to the data used here USD swap spreads have *no impact* on the Hong Kong dollar swap rates once the effect of the US treasury curve and the effect of short term liquidity is taken into consideration. This is consistent with our hypothesis that swap spreads contain macroeconomic information concerning the aggregate credit risk of the domestic firms in a given economy.

Tests on the third hypothesis can be found in block exogeneity tests in Table 3, which in fact contains all the relevant significance levels concerning the F-test statistics on the feedbacks between the variables in system (13). The table can be regarded as a direct estimate of the significance of all the A_{ij}, i = 1,..,5; j = 1,..,5. The main point is that the sub-block of coefficients that show the effect of past Hong Kong swap rates on the current swap rates is quite significant with complex dynamics. It indicates that even after taking into account the US treasury curve and the liquidity effect through Hibor and Libor; Hong Kong swap rates are still informative on the Hong Kong economy.

5.4. Additional empirical work

A few other procedures are tried on the swap data. In particular we look at the impulse response functions for Hong Kong swap rates to the variables shown in Table 3. In general, results are consistent across different length of maturities. Impulse responses for the 5-year HKD swap rates are presented in Figure 5 and Figure 6. They allow us to detect the contemporaneous and ensuing impacts from all the variables on Hong Kong swap rates. Each graph reveals the responses of the 5-year Hong Kong swap rates when a one-standard-deviation innovation is imposed on one of the variables in the system. We trace out the responses of the 5-year Hong Kong swap rates over a period of 100 days after the initiation of the shock.

The results confirm the main conclusions that we report in Tables 1-3. USD swap spreads and Libor are uncorrelated with HKD swap rates once the effects of the US Treasury curve and Hibor are filtered out. The most prominent effects that can be observed are from the 3-year US Treasury, the 3-year and 5-year HKD swap rates, and the relevant effects are statistically significant.

Now, we re-run the same regression only for the period from the third week of October 1997 to early December 1998 and perform Granger causality tests, since it is of special importance to check whether the above regression results hold for the Hong Kong market during the Asian financial crisis. Table 4 shows the results under the null hypothesis that the probability of each of the 17 variables Granger-causing Hong Kong swap rates is zero. As can be seen, only the 4-year US Treasury rate and the 3-year Hong Kong swap rate itself would Granger-cause the 3-year Hong Kong swap rate at the 1 percent significance level. No other variables are detected to exert a Granger-causality impact on the Hong Kong swap rates. Surprisingly, during this sub-sample period when Hong Kong was hit by the Asian crisis, regression results would not generally support hypotheses 1 and 3. But, we need to keep in mind that this is an extreme time period when different sectors of the Hong Kong economy experienced disruptions in terms of liquidity or solvency.

6. Conclusions

In this paper, we have examined the extent of swap curve dynamics across USD and HKD markets. Our main concern is to see whether the Hong Kong swap curve contains a component that is exogenous to the USD related variables. We test three essential hypotheses in order to explore the relationships among the USD Treasury curve, USD swap spreads, the HKD swap curve, and the Hibor and Libor rates by mainly adopting block exogeneity tests and impulse response functions.

The following conclusions have been derived from our analysis: (a) due to the existence of the Hong Kong dollar peg system, the US Treasury curve invokes significant responses on the HKD swap curve; however (b) both USD swap spreads and Libor fail to provide valuable information on the dynamics of HKD swap rates; (c) as expected, Hibor rates play a role in determining Hong Kong swap rates; and (d) most importantly, the Hong Kong swap curve itself contains rich information over and above that provided by the sovereign yield curve and the standard measures of market liquidity.

The findings of this study and their implications suggest that using sovereign yield curves and concentrating only on the risk premia associated with the breakdown of the currency peg is not sufficient for policy making in Hong Kong. With a component that is exogenous to the USD related variables; Hong Kong swap spreads and swap curves should be carefully monitored in order to assess economy wide risks and to conduct macroeconomic policy.

References

Brace, A., M. Musiela and E. Schlögi (1998), *A simulation algorithm based on measure relationships in the lognormal market models*, Preprint.

Deutsche Bank (2003), Global Market Research, The Hong Kong Bond Market, June.

Deutsche Bank (2002), Global Securities Services, The Hong Kong Country Guide, March.

Hull, J. (2000), *Options, Futures, and Other Derivatives*, 4^{th} ed., New Jersey: Prentice Hall.

Jamshidian, F. (1997), "Libor and swap market models and measures," *Finance and Stochastics*, 1: 293-330.

Musiela, M. and M. Ruthkowski (1998), *Martingale Methods in Financial Modelling*, Springer-Verlag.

Neftci, N.S. (2003), *Principles of Financial Engineering*, Academic Press, Forthcoming.

Table 1. US Treasury Yields Do Influence HKD Swap Rates

Maturity	F-Test
3 year	3310
4 year	2557
5 year	1853
7 year	1642
10 year	1417

Table 2. USD Swap Spreads Do Not Influence HKD Swap Rates

Maturity	Unrestricted	Restricted	F-Test
3 year	0.0141	0.0143	0.90
4 year	0.0109	0.0111	0.96
5 year	0.0091	0.0093	1.18
7 year	0.0073	0.0075	1.57
10 year	0.0069	0.0070	0.96

Table 3. Block Exogeneity Tests

Variable	1	2	3	4	5	6	7	8	9
1. HIBOR	0.00	0.00	0.20	0.54	0.98	0.97	0.88	0.66	0.72
2. LIBOR	0.61	0.00	0.01	0.31	0.64	0.65	0.16	0.00	0.02
3. UST 3	0.76	0.24	0.00	0.12	0.44	0.08	0.2	0.06	0.59
4. UST 4	0.95	0.15	0.00	0.00	0.31	0.02	0.29	0.15	0.61
5. UST 5	0.89	0.04	0.01	0.71	0.35	0.00	0.39	0.3	0.69
6. UST 7	0.88	0.17	0.04	0.43	0.31	0.00	0.94	0.32	0.60
7. UST 10	0.92	0.12	0.52	0.64	0.07	0.04	0.00	0.41	0.90
8. US 3SS	0.33	0.14	0.14	0.21	0.44	0.52	0.40	0.00	0.14
9. US 4SS	0.42	0.05	0.58	0.55	0.14	0.81	0.40	0.00	0.00
10.US 5SS	0.59	0.06	0.64	0.88	0.23	0.43	0.83	0.06	0.45
11.US 7SS	0.59	0.12	0.37	0.55	0.13	0.19	0.19	0.68	0.69
12.US 10SS	0.84	0.04	0.22	0.73	0.47	0.22	0.49	0.15	0.30
13.HKS 3	0.00	0.76	0.32	0.68	0.42	0.85	0.49	0.43	0.45
14.HKS 4	0.00	0.92	0.73	0.67	0.37	0.75	0.53	0.60	0.54
15.HKS 5	0.00	0.90	0.86	0.34	0.17	0.46	0.24	0.88	0.45
16.HKS 7	0.00	0.91	0.97	0.26	0.05	0.19	0.05	0.85	0.46
17.HKS 10	0.00	0.95	0.98	0.29	0.03	0.17	0.02	0.95	0.65

Variable	10	11	12	13	14	15	16	17
1. HIBOR	0.72	0.73	0.84	0.00	0.06	0.69	0.10	0.00
2. LIBOR	0.51	0.54	0.76	0.00	0.00	0.45	0.95	0.95
3. UST 3	0.12	0.14	0.80	0.38	0.17	0.29	0.97	0.83
4. UST 4	0.06	0.18	0.95	0.30	0.32	0.44	0.99	0.88
5. UST 5	0.01	0.18	0.96	0.35	0.55	0.51	0.96	0.80
6. UST 7	0.03	0.06	0.97	0.33	0.46	0.36	0.97	0.88
7. UST 10	0.24	0.21	0.85	0.42	0.62	0.36	0.92	0.90
8. US 3SS	0.05	0.21	0.71	0.52	0.55	0.50	0.57	0.17
9. US 4SS	0.00	0.29	0.22	0.68	0.78	0.62	0.46	0.19
10 US 5SS	0.00	0.10	0.18	0.33	0.53	0.67	0.25	0.59
11.US 7SS	0.00	0.00	0.00	0.65	0.85	0.77	0.24	0.11
12.US 10SS	0.04	0.41	0.00	0.48	0.80	0.84	0.74	0.68
13.HKS 3	0.95	1.00	0.90	0.00	0.00	0.00	0.00	0.11
14.HKS 4	0.82	0.98	0.93	0.00	0.00	0.01	0.00	0.31
15.HKS 5	0.78	0.99	0.68	0.12	0.00	0.00	0.00	0.23
16.HKS 7	0.64	0.97	0.39	0.02	0.00	0.00	0.00	0.06
17.HKS 10	0.47	0.94	0.22	0.00	0.04	0.00	0.00	0.00

Note: (1) This table is split into two parts. The bottom part is a continuation of the upper.

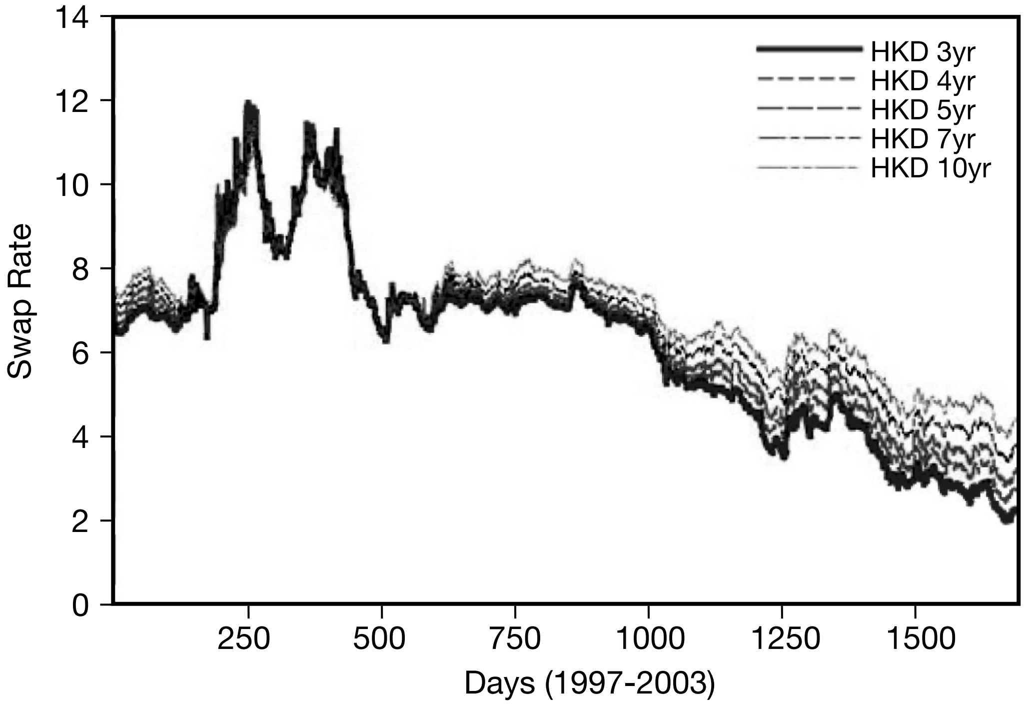
(2) The seventeen variables are respectively: HIBOR, LIBOR, 3-,4-,5-,7-,10-year US Treasuries, 3-, 4-,5-,7-,10-year US dollar swap spreads, and 3-,4-,5-,7-,10-year HK dollar swap rates.

Table 4. Granger Causality Probabilities for HKD Swap Rates during the Time Period of the Asian Financial Crisis

	3 year	4 year	5 year	7 year	10 year
Hibor	0.38	0.38	0.31	0.36	0.33
Libor	0.11	0.12	0.13	0.28	0.42
UST 3	0.71	0.79	0.83	0.60	0.51
UST 4	0.01	0.05	0.23	0.38	0.68
UST 5	0.57	0.54	0.45	0.60	0.65
UST 7	0.57	0.74	0.73	0.79	0.80
UST 10	0.54	0.65	0.52	0.56	0.58
US 3SS	0.58	0.50	0.54	0.54	0.46
US 4SS	0.64	0.61	0.78	0.76	0.64
US 5SS	1.00	0.99	1.00	0.97	0.91
US 7SS	0.71	0.82	0.79	0.80	0.82
US 10SS	0.67	0.71	0.62	0.87	0.91
3 year	0.01	0.13	0.54	0.43	0.36
4 year	0.12	0.16	0.58	0.49	0.52
5 year	0.34	0.49	0.31	0.31	0.21
7 year	0.31	0.26	0.15	0.04	0.11
10 year	0.14	0.25	0.13	0.11	0.18

Note: The probabilities in the columns reflect the Granger-causal impact of all the variables on the 3-year, 4-year, 5-year, 7-year and 10-year Hong Kong swap rates.

Figure 1. Hong Kong Dollar Swap Curves and US Dollar Swap Curves (3, 4, 5, 7 and 10-year maturities are used.)



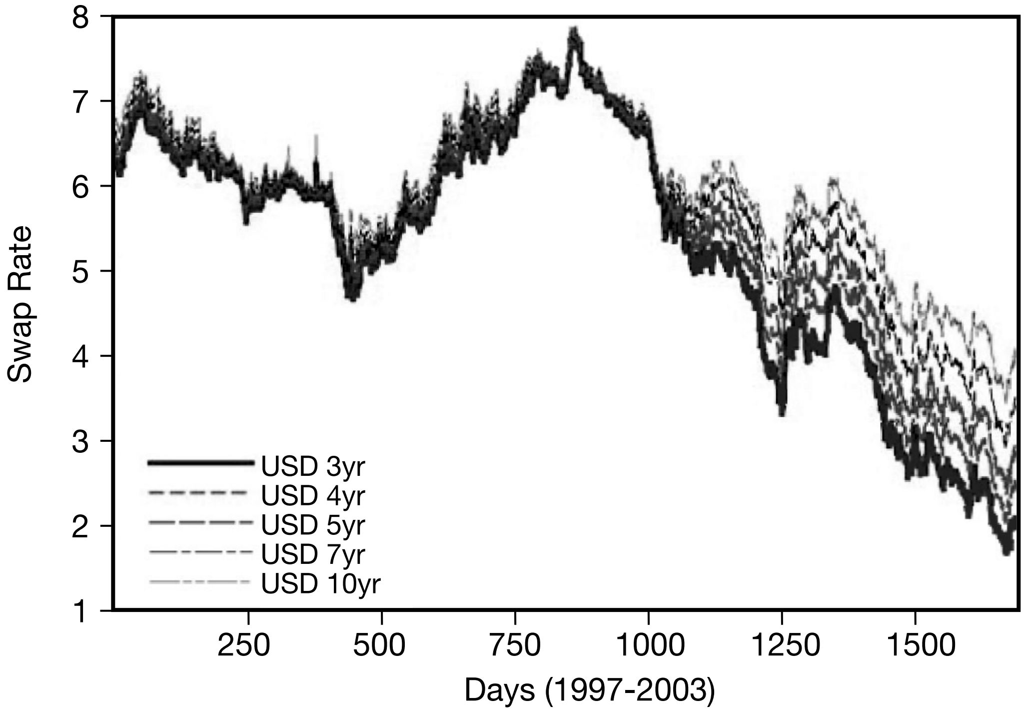


Figure 2. Term Structures of Swap Rates, US vs. Hong Kong (1997-2003)

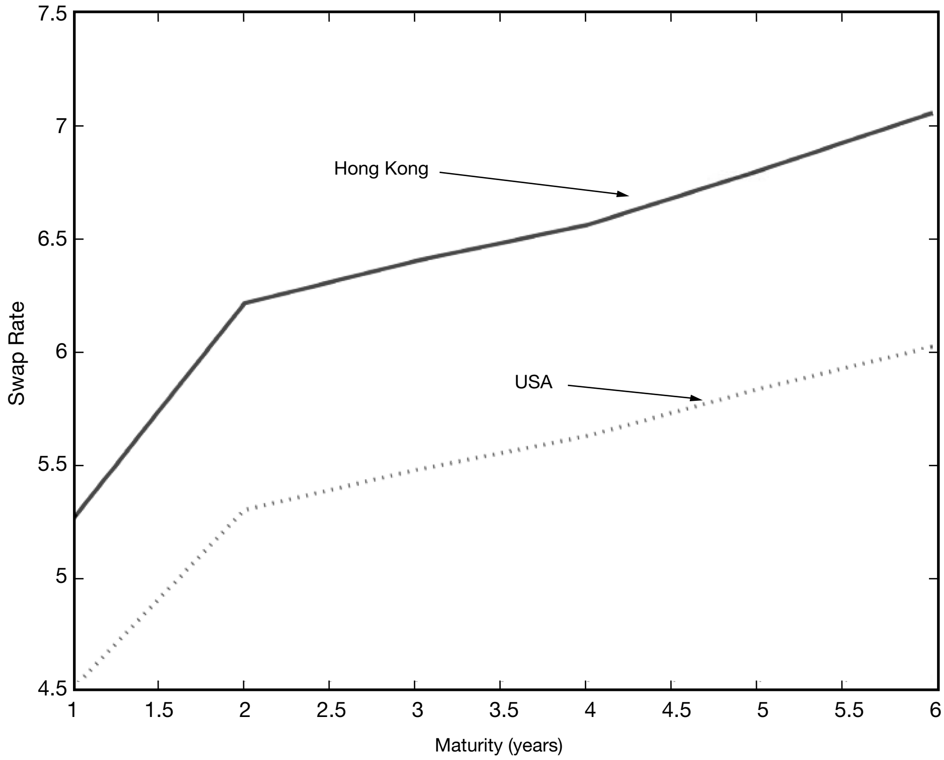


Figure 3. Difference Between 5-year USD and HKD Swap Rates

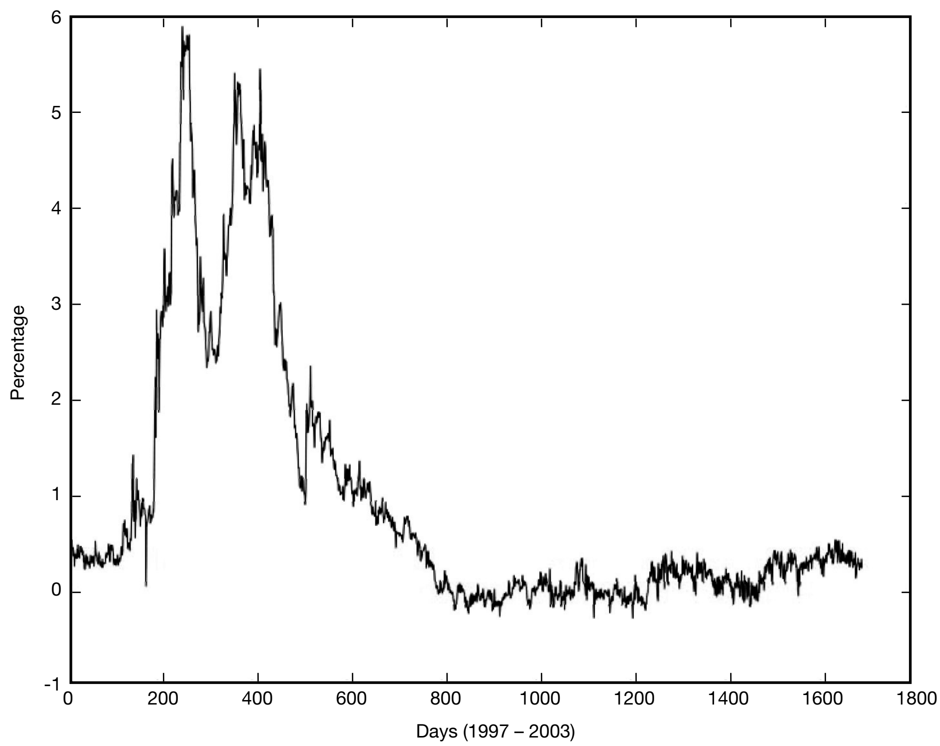


Figure 4. USD vs. HKD 5-year Swap Rates (subsample)

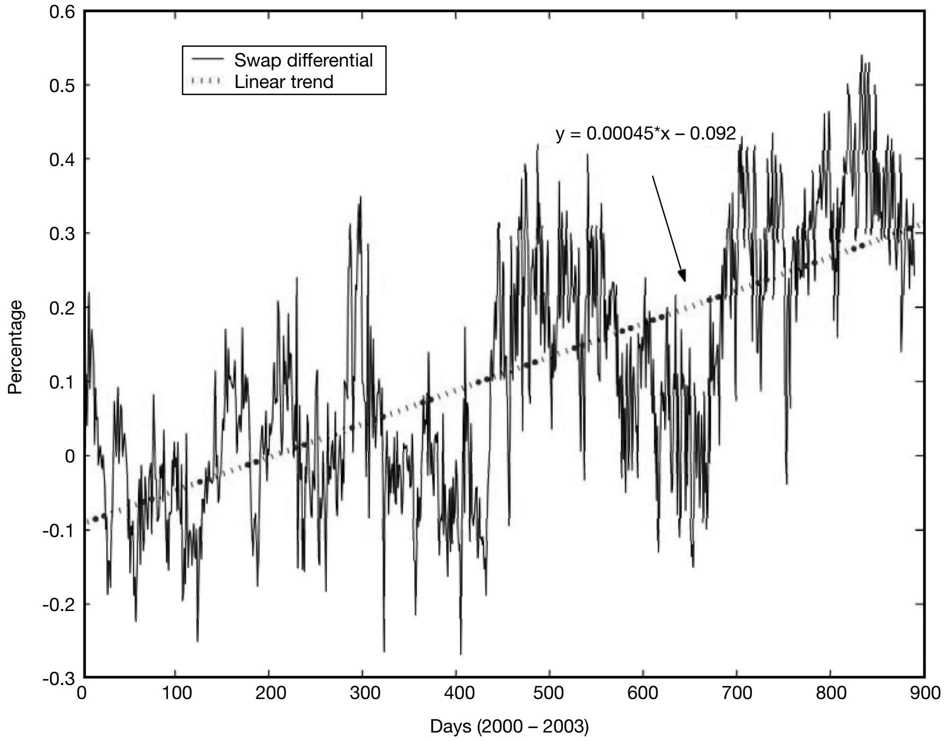
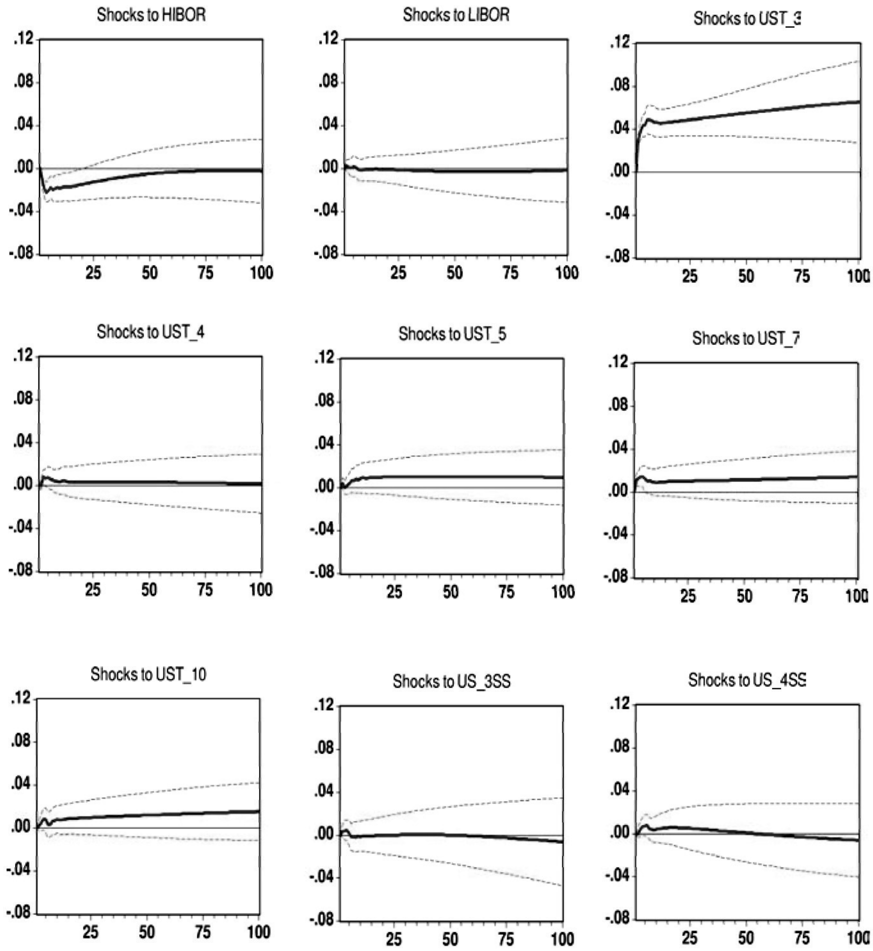
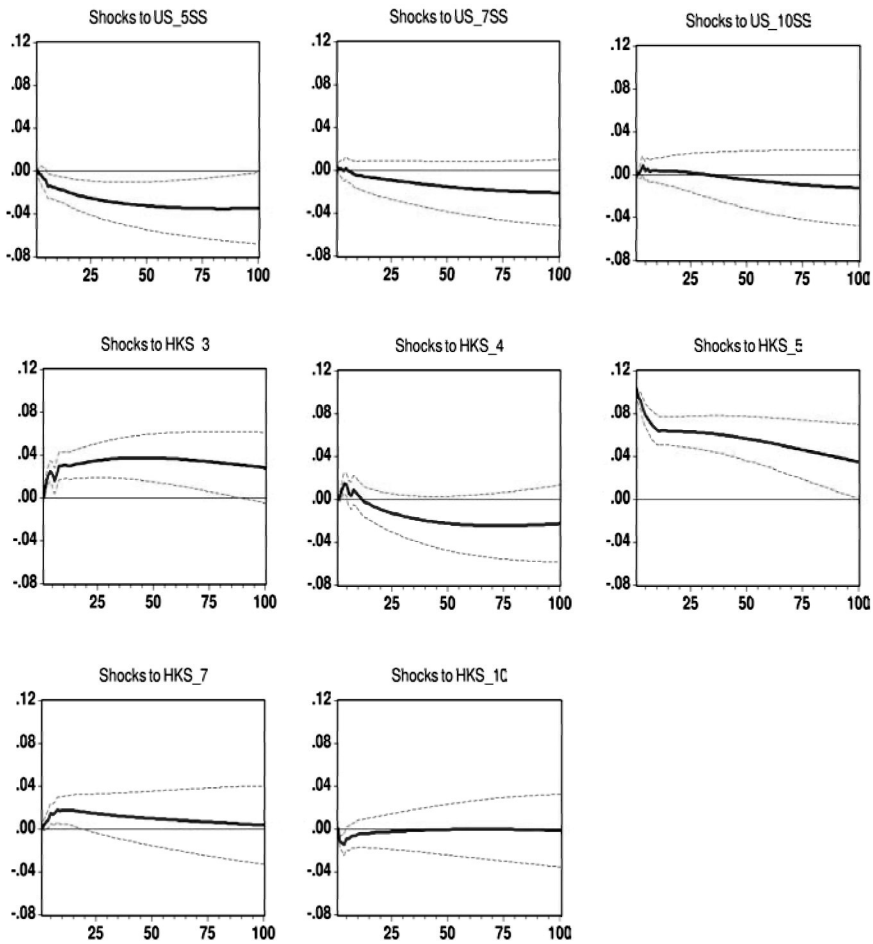


Figure 5. Impulse Response Functions.



Notes: A seventeen-variable VAR is estimated. Each small graph shows the responses of Hong Kong swap curve (5-year tenor) to the shocks imposed on each variable over a period of 100 days. Estimations are done by Monte Carlo. Plus/minus two standard deviation bands (dashed lines) are displayed along with the impulse responses.

Figure 6. Impulse Response Functions (continued).



Notes: The variables are respectively 3-month HIBOR, 3-month LIBOR, US Treasuries, US dollar swap spreads, and Hong Kong dollar swap rates all with 3, 4, 5, 7, 10-year maturities.