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THE US TREASURY MARKET IN AUGUST 1998: UNTANGLING THE EFFECTS OF HONG KONG AND RUSSIA WITH HIGH FREQUENCY DATA

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The US Treasury market in August 1998: Untangling the effects of Hong Kong and Russia with high frequency data*

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Abstract

The second half of August 1998 was dominated by two events. From 14 to 28 August the Hong Kong Monetary Authority (HKMA) intervened in the Hong Kong equity markets to prevent a speculative double play against their currency board. On 17 August Russia announced its default on sovereign bonds. This paper demonstrates that the HKMA interventions had a substantial impact on the outcomes for US Treasury markets during this period. Using a careful analysis of high frequency bond market data both events are shown to intersect in the US Treasury market, despite having originated from seemingly unrelated shocks. On this evidence the shocks emanating from Hong Kong were important for the US Treasury market. The lesson for policy makers is that major markets play an important role in transmitting and absorbing the effects of unrelated shocks.

JEL: F37, F42

Keywords: Russia, Hong Kong, financial crises, US Treasury market, high frequency data

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1 Introduction

During the third quarter of 1998 two major financial market events occurred almost simultaneously. On Friday, 14 August, the Hong Kong Monetary Authority (HKMA) began intervening in the Hong Kong equity market to prevent a speculative double play against their currency board. On the next trading day, Monday, 17 August, Russia announced that it would suspend its repayments of sovereign debt. The following months represent a period of unprecedented volatility in the secondary market for sovereign debt instruments. Spreads betweeen developing economy bonds and equivalent US Treasury benchmarks widened to an extraordinary degree, in turn contributing to the crisis associated with the near collapse and subsequent rescue of Long Term Capital Management (LTCM), the US-based hedge fund.

Most studies of this period concentrate entirely on the effects of the Russian default as the trigger for the subsequent financial market turmoil. For example, Jorion (2000) in assessing the plight of LTCM, Hwang and Salmon (2004) who attribute decreased herding effects in mid 1998 to the Russian crisis, Hernández and Valdéz (2001) who consider the effects of trade links on crisis transmission, and Dungey, Fry, Gonzalez-Hermosillo and Martin (2005) who measure contagion effects in bond markets. Each of these studies uses financial data sourced at daily or weekly frequency.

Figure 1 shows the daily spread between US dollar denominated sovereign debt from a range of developing economies relative to the 10 year US Treasury bond yield.[1] In August 1998 there is a dramatic increase in the spreads of each of these countries, and in Latin America (not shown). The sovereign spreads increase at a relatively steep but sustained rate over the period from 14 to 28 August 1998, and thereafter retain a flatter profile.

At the same time, market reports suggest a substantial flight-to-quality into US Treasuries in the second half of August 1998, particularly at the long

[1]The daily data consists of long term US dollar-denominated sovereign debt, from a database collected from national sources. Brady bonds were avoided with the exception of Bulgaria and Poland where alternatives were not available. Sources are fully documented in Dungey, Fry, Gonzalez-Hermosillo and Martin (2005). These authors also consider a longer period, confirming that emerging market spreads remained around this same level over the remainder of 1998.

end. This is shown in daily data in Figure 2. Although some of the flight-to-quality occurred between 14 and 28 August, US yields across the term structure declined more after 28 August, when the details of the Russian GKO restructure and the problems besetting LTCM were becoming more apparent. Bond prices in fact continued to rise for the remainder of the third quarter of 1998.

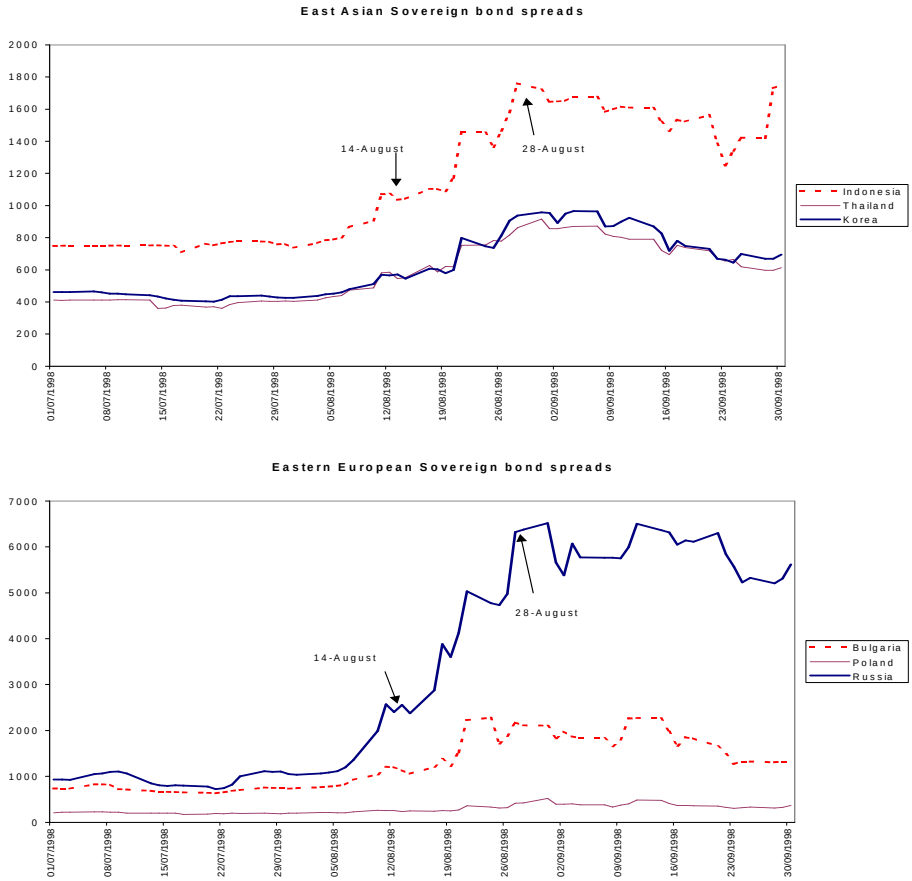

Figure 1: Emerging market sovereign bond spreads.

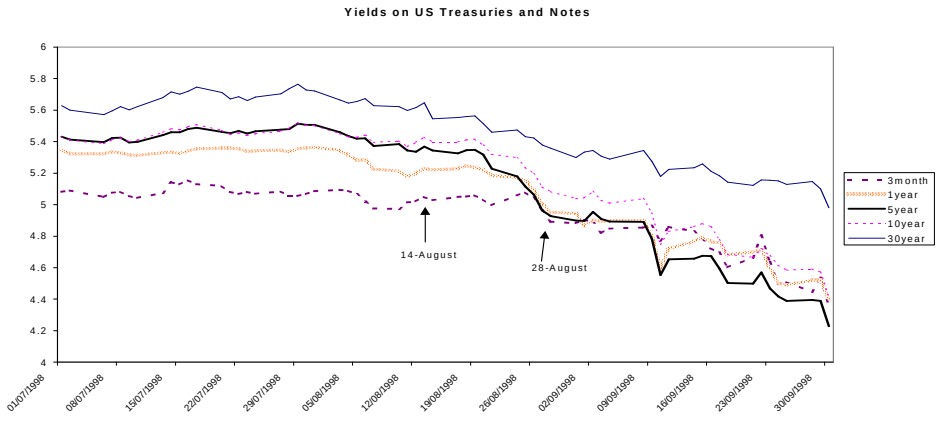

Figure 2: US Treasury yields.

In order to assess the timing of the flight to quality related to the Russian and Hong Kong crises in August 1998, one needs not only daily data, but also even higher frequency. In this paper we focus on the interaction of the Russian and Hong Kong financial crises in high-frequency data as played out in the US Treasury market from 14 to 28 August 1998. An examination of high frequency US Treasury data for this period reveals an important and perhaps dominant role for the HKMA interventions in determining outcomes in the US Treasury market.

We analyse four distinct characteristics of high-frequency trading —trading volume, net order flow, realized volatility and bid-ask spreads, to assess the importance of HKMA actions. The volume of US Treasuries traded during the period was relatively high and peaked on 27 and 28 August, the last two days of the HKMA interventions. Net order flow indicates a predominantly sellers' market in some maturities for US Treasuries on key dates associated with the Russian default and on the last days of the HKMA intervention.[2] Realized volatility for the fortnight declined from a quarter high achieved just prior to the period under examination, and realized covariance between

[2]In contrast, an alternative safe-have asset market, the German bund, has been studied by Upper (2001) and Upper and Werner (2002) who show that in the period immediately following the Russian default German bunds experienced an increase in volume traded, a decrease in transaction size, an increase in realized volatility and an increase in the bid-ask spread.

the different maturities of US Treasuries increased only from 27 August onwards. Lastly, the bid-ask spread on US Treasuries was relatively stable until 27 August, followed by a sustained widening.

Our analysis suggests that the evolution of the data is consistent with a strong role from the HKMA interventions; a finding supported by market participants' views in the review of the 1998 crisis by the BIS Committee on Global Financial Stability; see Committee for Global Financial Stability (1999). The emerging conclusion is that the Hong Kong intervention had a substantial role to play in the behaviour of the US Treasury market during this period.

The rest of the paper proceeds as follows. Section 2 sets the scene and briefly reviews the background of each event. Section 3 analyzes the high-frequency data on the US Treasury market during the second half of August. Section 4 places this evidence in the context of events and characteristics of both the Russian and Hong Kong financial markets and economic developments at the time. It raises the question of which events can be seen as consistent with the observed empirical evidence and attempts to reconcile the observed data regularities with the events of the second half of August. Section 5 provides some concluding remarks.

2 Background to the Crises

In the 10 months prior to August 1998, the HKMA had successfully defended against at least three speculative attacks on the Hong Kong dollar, largely through the use of higher domestic interest rates. However, these incidents and the corresponding decline of the Hong Kong stock market alerted speculators to a potential 'double play': speculators shorted the stock market through the Hang Seng futures market, and simultaneously pressured the Hong Kong currency. The speculators stood to gain if the HKMA raised interest rates and equity values fell, or if the currency board broke and their foreign exchange positions became profitable. Speculators were only facing the risk that the HKMA would not behave as previous experience predicted and would somehow break the link between supporting the currency and rais-

ing interest rates, thereby dropping equity markets—one possibility would be by direct intervention in the foreign exchange markets, but there the speculators had reasonably good models of central banks' difficulties in holding a currency peg against consistent attack.

The HKMA first intervened in the Hong Kong stock market on 14 August 1998; see Yam (1998) and HKMA (1998: pp125). This was unanticipated by the markets, and a new strategy for a central bank, particularly one as (previously) non-interventionist as the HKMA. The intervention continued until 28 August, the settlement date of the Hang Seng futures contract on which the speculators' short position was based. In the HKMA's favour was that a known break point existed for the speculators, in that the short play on the equity market would recede with the expiration of the current futures contract on 28 August 1998. This was in fact what the HKMA managed, but the financial outlays were enormous, although subsequent (world-wide) rises in equity markets then made the interventions hugely profitable for the HKMA.[3] Immediately following the futures contract's expiration, the HKMA ceased intervening and let the Hang Seng index fall, but was left with an unprecedented share portfolio of approximate $HK200 billion, of which the majority was to be returned to the market at some point; see HKMA (1998, p.3). To fund its massive intervention program, the HKMA liquidated some of its portfolio of reserve assets, which primarily comprises US Treasuries (HKMA 1999).[4] In the period from 14 to 28 August the HKMA potentially sold up to $US15 billion of US Treasuries.

July and August 1998 also witnessed deepening concerns about the Russian financial markets partly due to poor economic fundamentals and banking system weakness. Many industrial countries, including the US, had large exposures to emerging markets, including Russian markets, through their banking system; see Van Rijckeghem and Weder (2003). On top of this, the

[3]Goodhart and Dai (2003) document that, of the $HK118 billion that the HKMA announced it spent on intervention between 14 and 28 August, approximately $HK11.5 billion were spent in the first week, $HK15 billion in the next 3 days, $HK19 billion on the day before the contract's expiration and a massive $HK72 billion on the final day.

[4]In February 2005 Hong Kong was listed as the 10th largest foreign holder of US Treasuries, holding some $US15 billion of securities.

US was particularly exposed through the actions of hedge funds such as Long Term Capital Management (LTCM) which had bet heavily on the narrowing of spreads between Russian and US bonds. The effects of the Russian crisis on LTCM are well documented in Jorion (2000) and Lowenstein (2001). Essentially the highly leveraged hedge fund experienced calls for cash to finance its outstanding positions that it simply could not raise extra funds to meet. To avert a crisis, the New York Federal Reserve co-ordinated a meeting of market participants who formed a recapitalisation plan released to the public on 23 September. The problems apparent with LTCM became increasingly public during September, outside the time frame of this paper.

During July 1998 both the World Bank and the IMF released further funds to Russia. A crucial element of the IMF program was that Russia make progress in restructuring its GKO debt market, particularly some settlement on debt writedown. On 13 August a letter from George Soros calling for a "modest devaluation of 15 to 25 percent" in the rouble and formation of a currency board was published in the *Financial Times*. Despite President Yeltsin's 14 August declaration that there would be no devaluation, on 17 August Russia suspended its short-term debt payments and allowed the rouble to float.

Following the default, a number of attempts were made to work out a credible plan for GKO debt restructuring. On 20 August the Russian Government announced an interim plan providing some payments to domestic creditors, but an indefinite freeze for international investors. Credit rating agencies responded with a downgrade. On 23 August the incumbent Kiryenko government was dismissed and it was not until 11 September that a new government was successfully formed under Primakov. A workable GKO restructuring scheme was not set out until December 12, and even that did not come into force until almost 4 months later.

The role of the non-resident investors was a critical part of the GKO renegotations; these investors continually rejected earlier schemes. Over 1998, many such investors were hedging their positions with forward rouble contracts with Russian banks. Although many Russian banks had already transferred their previous GKO holdings to non-GKO assets, they were massively

short in these forward contracts; see Steinherrr (2004) for details of some particular bank's exposures. The majority of this exposure was to foreign investors, prompting concern about the banks' default potential, and the resulting uncertainty may have risen towards the end of the month. However, the only bank with large forward exposure put under administration in August was SBS-Agro, and the only major bank to have its licence revoked in this period was Bank Imperial, not noted as having major forward contract exposure in July 1998.[5] In sum, most of the new information about the state of the Russian banking system and the subsequent collapses seems to have occured primarily either bfore August 23 or after 28 August.

A crisis in an emerging market such as Russia experienced is often associated with a flight-to-quality, that is excess demand for US Treasuries. In addition, uncertainty provokes a flight-to-cash, so that the demand for the short end of the US term structure is very high indeed; see Longstaff (2004). As the following sections show, the mix of the flight to quality and flight to cash provoked by the crisis in Russia, and the HKMA's intervention which was in all probability funded from sales of US Treasuries, led to interesting interactions in the US Treasury market during the last fortnight of August. The role of events in Hong Kong is arguably greater than previously credited in the literature.

3 High Frequency Evidence

We use daily and high frequency (5 minute) GovPX trading data on the US Treasury market extracted from tick-by-tick records of the 2, 5 and 10 year maturities for the third quarter of 1998. According to Fleming (2003: p.86), in 1998 the GovPX interbroker market covered approximately 57 percent of the total market (and has been falling dramatically since). For the purposes of examining the 1998 crises, this is the most comprehensive US bond high-

[5]Eventually some 200 banks had their licences revoked (Steinherr (2004)). There were three important bank mergers amongst banks with outstanding forward contracts announced on 25 August, 26 August and 3 September; a chronology is provided in Shuster (1998).

frequency database.[6]

3.1 Traded volume

The main characteristics of the data on volumes for the US Treasury bonds are extracted from the high frequency data covering July, August and September 1998. Using intraday data allows construction of total trading volumes on given days across different trading locations. Data are recorded on a 24-hour basis, starting at approximately 6pm New York (NY) time each day. Fleming (1997) segments a trading day into three periods: Tokyo trading from 7:30 pm to 3.00 am NY time, London trading from 3.00am to 7.30 am NY, after which time trading switches to NY. Although most of the price discovery occurs in NY, the volume characteristics of trade in US Treasuries in the non-NY trading periods can shed valuable light on the contribution of the Hong Kong double play on the US Treasuries market.

Table 1 shows the average daily volume in $US billion for different maturities across different time zones for the period 2 July 1998 to 30 September 1998. We also consider two relevant subperiods: a non-crisis period before 17 August 1998 (pre-Russian default), and a crisis period from 17 August to 30 September 1998 (post-Russian default). Treasury volume traded on GovPX during the crisis exceeds that in the non-crisis period, consistent with the results of Furfine and Remolona (2002). Volume was greatest for the 2 year issue, and goes down with maturity. The maximum daily traded volume for all maturities occurred during the crisis period and is some 1.5 to 2 times greater than the average volume for the entire period. Minimum daily volumes occurred in the non-crisis period and were between one-quarter and one-half the average volume for the total period.

In the total and non-crisis data, the vast majority of trades clearly occurs

[6]The GovPX database has been characterised by Fleming (1997) based on half-hour observations. It covers five of the six brokers in the interbroker market, constituting a substantial portion of trade in the short end of the US Treasury market, up to and including the 5-year maturity, and somewhat less for longer-dated bonds. The database has recently been used by Brandt and Kavajecz (2004), Green (2004), Boni and Leach (2004) and Chordia, Sarkar and Subrahmanyam (2005). The algorithms used to extract the data analyzed here are available from the first author.

in the NY time zone for all maturities, with the Tokyo time zone quite inactive on average. Indeed, not only is total traded volume higher on average during the crisis period, but this is disproportionately true in non-NY trading.[7] In NY trade, average volume in the 5 year issue increased by around 150 percent during the crisis period, but by almost 200 and 250 percent in London and Tokyo respectively.

The day with the highest volume of trade in the 2 and 5 year securities is 28 August, when the Hang Seng futures contract expired. Volume for all maturities for this date is shown in Table 2. It also includes volume for 27 August, another very heavy trading day. The behaviour of volume in the different time zones on 27 and 28 August indicates the importance of the expiry of the Hang Seng futures index for this market. The futures contract closed with Hong Kong trading on 28 August - slightly after the opening of the London markets. Thus the last opportunity for NY-based trades was 27 August, precisely the day with highest volume for the 2 and 5 year maturities in the quarter.[8]

This was coupled with unprecedented activity in the Tokyo time zone. As Table 1 shows, average volume in the Tokyo trading time is very low across maturities, particularly in the non-crisis period. Average Tokyo trade volume in the 5 year maturity for the non-crisis period is $US130 billion, but this approximately doubled for the crisis period, influenced by the massive $US1199 billion traded in this time zone on 28 August. To put this in perspective, on average around 2 percent of trade in the non-crisis period occurred in the Tokyo time zone, but this jumped to over 10 percent on this one particular day. A similar pattern emerges for the 2 year maturity. In the longer dated maturities the 27 and 28 of August do not represent the maximum volumes observed in the third quarter of 1998, nevertheless trade volume is up by around 160 percent on the pre-crisis average volumes for 27 August and 130 percent for 28 August for the 10 year bond. Thus the

[7] The direction of the association between volume and liquidity is not clearly determined in the literature. There are a number of examples of higher volume during periods of stress; for example see Fleming (2003).

[8] 10 and 30 year trading volumes are higher on the day of the LTCM recapitalisation announcement; these are not shown here but are available on request from the first author.

anticipation of the Hang Seng futures contract expiry, and the actions of both speculators and HKMA in playing out the speculative scenario seem to have been influential on the US Treasury market in that period. Although it was technically possible for the speculators to have rolled their futures market positions into the September contract, it seems that the HKMA acted in that market to make this an unattractively expensive option; Goodhart and Dai (2003:chapter 5).

The two other dates singled out in Table 2 are 14 and 17 August, the first day of HKMA intervention and the day of Russia's debt payment suspension, respectively. Volume on 14 August was higher than the average for non-crisis days. This trade was focused in the NY time zone, which occurs after the Hong Kong intervention. On 17 August, the Hong Kong market was closed, and uncertainty abounded about the implications of the Russian announcement.

Nevertheless, the volume traded on 17 August was relatively low, as was the maximum volume traded in any 5 minute interval during the day. This could reflect the market's difficulty in absorbing the previous two days' information, but this is not evident in the market's quotation activity. In particular, the ratio of number of trades enacted to quotes posted is relatively similar at around 0.12 in each market, and the average volume per trade does not alter very much for the 5 and 10 year issues across the dates shown in Table 2. However, the average time between trades in the NY trading zone does change across the crisis period. On the high volume days of 27 and 28 August the average time between trades is less than that recorded for the lower volume days of 14 and 17 August. The average trade size is either unchanged or slightly lower during the higher volume days at the end of August, consistent with the lower time between trades and, as noted by Fleming (2003, chart 7), the quote size also falls. The US Treasuries market operates as an expandable limit order book; meaning that once an initial bid or ask has been accepted the two parties negotiate the final volume to be transacted at this price. The time taken from the initial hit or take until the final transaction volume is agreed is known as the workup time; see Boni and Leach (2004). The time taken to work up a trade is not notably

different across the crisis days shown in the table, being around 17 seconds for the 2 year, 14 seconds for the 5 year and 6 seconds for the 10 year issue. This is entirely consistent with the fact that, despite changes in overall volume transacted, the size of the average trade changes very little across these days.

The conclusion arising from the volume characteristics of the market is that some of the higher volume of US Treasury trade observed in the latter half of August is almost surely associated with the situation in Hong Kong.

3.1.1 Seasonality

To get a better feeling whether the volume observed is just coincidentally greater or smaller on the days of interest, we now estimate controls for regular events which are known to affect the market. For example, Fleming and Remolona (1999) find that US Treasury trading volume responds to macroeconomic announcements: there is a muted initial response and a larger and prolonged subsequent lift in volume. Chaboud et al (2004) have recently found a similar result for currency markets. Seasonal effects are estimated from the daily GovPX volume data from January 1992 to June 1998 for each of the 2, 5 and 10 year maturities. Although high frequency deseasonalising can also be undertaken (Anderson and Bollerslev (1997) and Bollerslev, Cai and Song (2000)), most interesting effects occur only a few times in the relatively short sample available, which includes the crisis period. However, using daily GovPX data on volumes it is possible to obtain a simple estimate of the size of day-of-the-week and end-of-the-month (issuance) effects on volume.

In the short sample examined above, 17 August is a Monday, 27 August is a Thursday, and 14 and 28 August are Fridays. Using a simple regression of day of the week and end month dummies on daily data, the volume effects for Mondays, Thursdays and Fridays respectively are found to be -1524, 447 and 145 million in the 2 year note; -1208, 779, 380 in the 5 year note; and -881, 332, -133 in the 10 year note. End-of-month effects are 145, -87 and -229 million dollars for the 2, 5 and 10 year maturities respectively.[9] Applying

[9]The regressions run included day of the week effects for Monday, Tuesday, Thursday

Table 1:

Volume traded in non-crisis (2 July to 14 August) and crisis (17 August to 30 September) periods in $US million per day.

		2 year	5 year	10 year
Average daily volume across time zones				
Total		7689	6724	4829
Non-crisis	total	5571	5555	4110
	max	12371	8746	6256
	min	1972	2947	2272
Crisis	total	10124	8148	5728
	max	15069	11213	7511
	min	5152	4112	3497
Average daily volume: Tokyo time zone				
Total		234	225	188
Non-crisis	total	159	130	132
	max	537	397	289
	min	0	2	0
Crisis	total	314	326	247
	max	1110	1199	595
	min	28	0	6
Average daily volume: London time zone				
Total		500	412	334
Non-crisis	total	310	281	208
	max	934	685	480
	min	113	60	37
Crisis	total	703	551	468
	max	2741	1312	11338
	min	75	98	103
Average daily volume: New York time zone				
Total		6952	6083	4306
Non-crisis	total	4931	4974	3644
	max	11008	8102	5978
	min	1784	2640	2121
Crisis	total	9104	7265	5010
	max	13344	9943	6908
	min	4926	3657	3090

Table 2:
Volume characteristics of particular crisis days in $US million per day

		2year	5year	10year
14-August-1998				
Total volume	Tokyo	71	111	96
	London	113	121	187
	NY	6443	5501	4027
max vol in a 5 min interval		743	231	259
17-August-1998				
Total volume	Tokyo	151	124	6
	London	75	331	185
	NY	4926	3657	3306
max vol in a 5 min interval		239	132	193
27-August-1998				
Total volume	Tokyo	213	337	264
	London	389	753	622
	NY	12206	9423	5728
max vol in a 5 min interval		611	240	291
28-August-1998				
Total volume	Tokyo	929	1199	501
	London	2741	785	704
	NY	11399	9229	4205
max vol in a 5 min interval		714	224	353

Table 3:
Trading and quoting activity by maturity in New York time zone

	2 year	5 year	10 year
Total sample			
activity=trades + quotes	211432	314596	269616
trades	27108	43963	36342
ratio of trades to activity	0.128	0.140	0.135
average volume per trade	16.22	8.72	7.49
14-August-1998			
activity	3143	4749	4355
trades	364	601	542
ratio of trades to activity	0.116	0.127	0.124
average volume per trade	17.70	9.15	7.43
average time between trades	1:46	1:03	1:10
17-August-1998			
activity	2313	3219	3192
trades	272	404	419
ratio of trades to activity	0.118	0.126	0.131
average volume per trade	18.11	9.05	7.89
average time between trades	2:15	1:32	1:28
27-August-1998			
activity	4943	7314	4930
trades	675	1054	702
ratio of trades to activity	0.137	0.144	0.142
average volume per trade	18.08	8.94	8.16
average time between trades	00:54	00:35	00:58
28-August-1998			
activity	6099	8919	5636
trades	873	1256	796
ratio of trades to activity	0.143	0.141	0.141
average volume per trade	13.06	7.35	5.28
average time between trades	00:50	00:35	00:58

*Note: The quoting activity is calculated by summing the number of ticks posted on GovPX *excluding* those associated with a trade. The number is necessarily an estimate as it is not always clear in the database which ticks clearly represent new market quotes. If anything, the number of quotes reported in the Table is likely to overestimate activity.

these adjustments to the data in Table 2 does not materially affect the picture presented in the previous section. The largest adjustment is to the 2 year volume on Monday, 17 August, where assuming the seasonal adjustment is made only in NY trading, the NY trade volume figure would rise to around (4926+1524) 6450 million, which is consistent with the total volume traded in NY on the 14 August, and well below the volumes traded on 27 and 28 August which are barely affected by the day of the week adjustment. Adjusting for intraday seasonality using a flexible Fourier transform, as suggested in Bollerslev, Cai and Song (2000) with a news dummy for the release dates for the employment situation, the CPI and retail sales revealed no discernible impact from these effects during this period.[10]

3.2 Net Order Flow

Net order flow refers to net purchases made during the day, calculated by compiling signed trades (purchases less sales) from the tick-by-tick data. Figure 3 gives the net order flow for the 2, 5 and 10 year maturities for the period 14 to 31 August. The columns in each case are the net order flow for each day. The thick line in each chart is the mean net order flow recently calculated by Brandt and Kavajecz (2004) for each maturity using GovPX data over the period January 1992 to December 1999 (for on-the-run bonds with maturities of 1-2, 2-5 and 5-10 years, these authors report mean net order flow of 246.909, 307.857 and 144.751 $US million respectively). The dashed lines represent 90% significance bands, again compiled from the data

and Friday and the last trading day of each month, which is the day of issue for new securities.

[10]Fleming and Remolona (1997) and Goldberg and Leonard (2003) find that the three categories of economic announcement with the greatest impact on the US Treasury market employment, inflation and output statistics. A single news announcement dummy was included for the release dates for the employment situation (2 July, 7 August, 4 September), the CPI (14 July, 18 August, 17 September) and retail sales (14 July, 13 August and 15 September). The news announcements dummies are active for 3 periods (15 minutes) from the announcement time of 8:30 am in each case, following the finding of Green (2004) that increased activity in the Treasury market associated with announcements is contained within a 15 minute window. We also considered the Fleming and Remolona (1997) window of impact of 70 minutes after the announcement, but it makes no discernible difference to the outcomes.

in Brandt and Kavajecz.[11] They note that average net order flow is positive in each of these maturities.

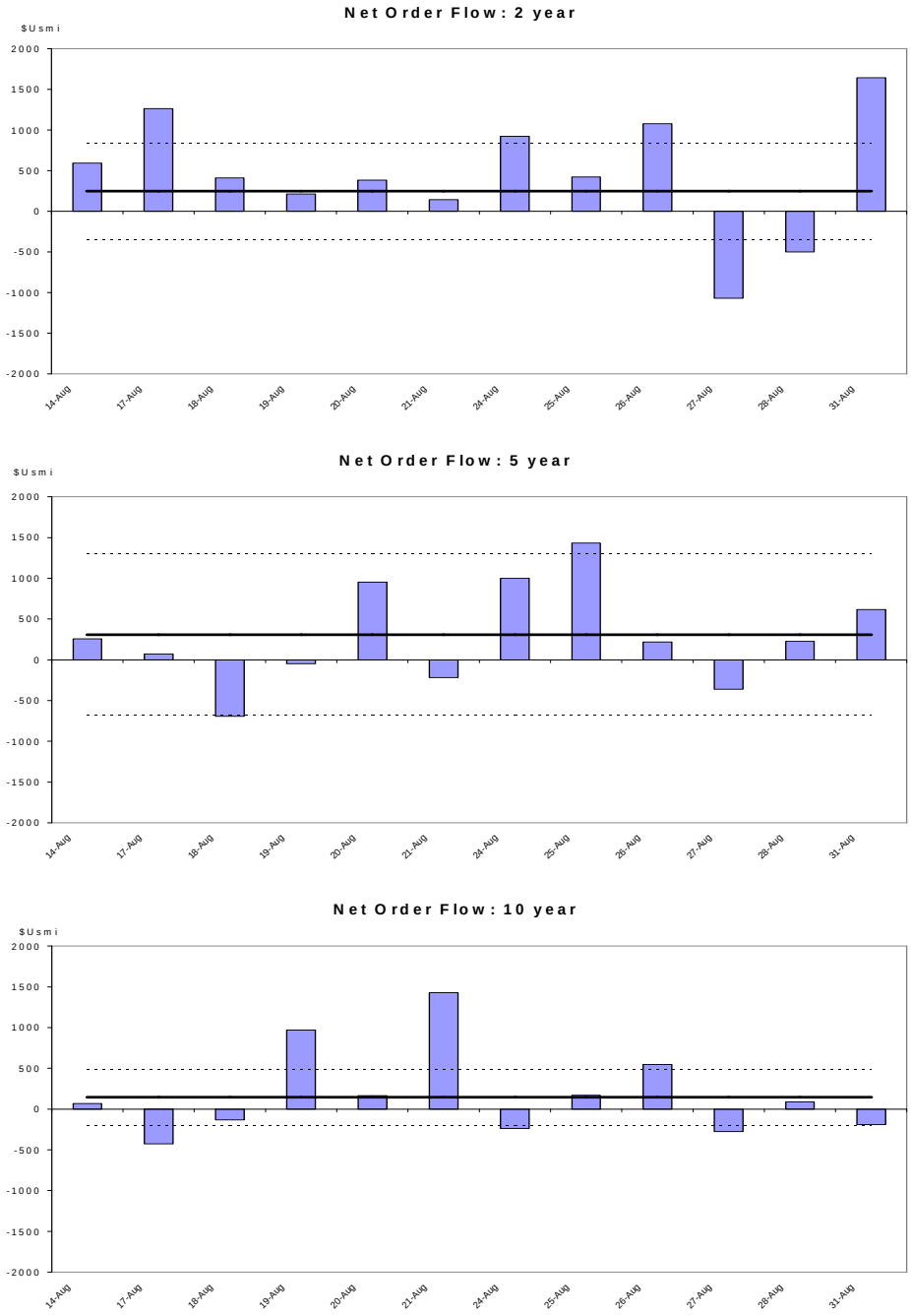

Figure 3: Net order flow across maturities.

[11]Brandt and Kavajecz (2004) report standard deviations of 594.361, 604.659 and 343.624 for on-the-run bonds of remaining maturity of 1-2 years, 2-5 years and 5-10 years respectively; see Table 1 in their paper.

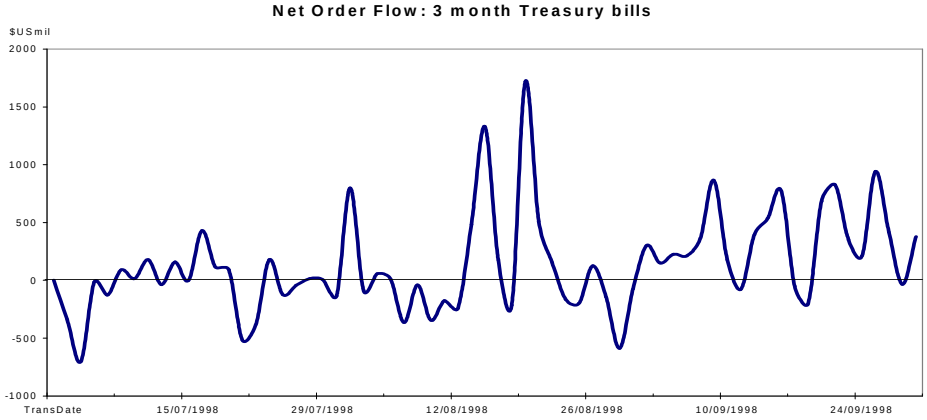

Figure 4: Net order flow short end.

In considering the events of August 1998 on the one hand, news about the Russian default should have created a flight to quality and hence a desire on the part of market participants to buy US Treasuries, which should show up in the net order flow as strongly positive net purchases. On the other hand, the HKMA is known to have funded its intervention in the stock market using its foreign reserve portfolio, which comprises mainly US Treasuries. This would release US Treasuries into the market, and if nothing else was going on, create excess takes in the market, represented as strongly negative net purchases. As the intervention went on, the amounts released into the market by the HKMA were progressively larger; Goodhart and Dai (2003).

Figure 3 indicates significantly negative net purchases on 17 and 18 August in the 10 year maturity and on 18 August for the 5 year maturity. Later in the fortnight, there are strongly positive net purchases in all maturities. This pattern suggests that the flight to quality was not the dominant factor in longer term bonds immediately following the Russian default. The exception to this is the 2 year maturities which were strongly positive net purchases on the 17 of August.

Given uncertainty about the composition of US Treasuries the HKMA may have sold to fund its interventions, two potential explanations are possible. First, the flight to quality may have been accompanied by a flight

to shorter maturity securities and cash; and, second, the role of the HKMA intervention may have been important in determining negative net purchases immediately following the beginning of the intervention period. An examination of high frequency data for US Treasury bills suggests a strong component of flight to cash at the very short end. As shown in Figure 4, which gives the net purchases for the third quarter of 1998, in the 3 month Treasury bill net purchases are dramatically higher during this period than the remainder of the quarter. The two large peaks correspond to 14 and 19 August. To put these figures in perspective the corresponding mean and standard deviation for 0-6 month securities for 1992 to 1999 reported by Brandt and Kavajecz (2004) are $US22.443 million and 322.111 million respectively. The picture presented around 14 to 18 August suggests a strong element of flight to cash, but is not completely consistent with a flight to quality at all maturities immediately following the Russian default.

However, on 27 August strong net sales are consistently evident across all maturities, including 3 month Treasury bills. This date was the last NY trading period before the expiration of the Hang Seng futures contract; in the last two days of intervention Goodhart and Dai (2003) estimate some $HK91 billion was spent on intervention.[12] On 27 August, the evidence supports the hypothesis that sales from the HKMA to fund their intervention activities dominated flight to quality effects from Russia.

3.3 Realized Volatility

The existing literature on price impact in the US Treasury market suggests that volume and price impact are not related; Boni and Leach (2004), Green (2004). This is consistent with a number of similar studies of equity markets such as Farmer et al (2004) for the London Stock Exchange.

In a crisis period with high volumes, a natural first response is to consider whether crisis days are related to large price movements. As shown in Figure 2 from Section 1, US Treasuries showed a slight decline in yields over the

[12] In fact, it is difficult to know when HKMA sales of US Treasuries would have been enacted in the US market, and the issue is further complicated by the different and non-overlapping time zones.

second half of August, and a more pronounced fall thereafter.

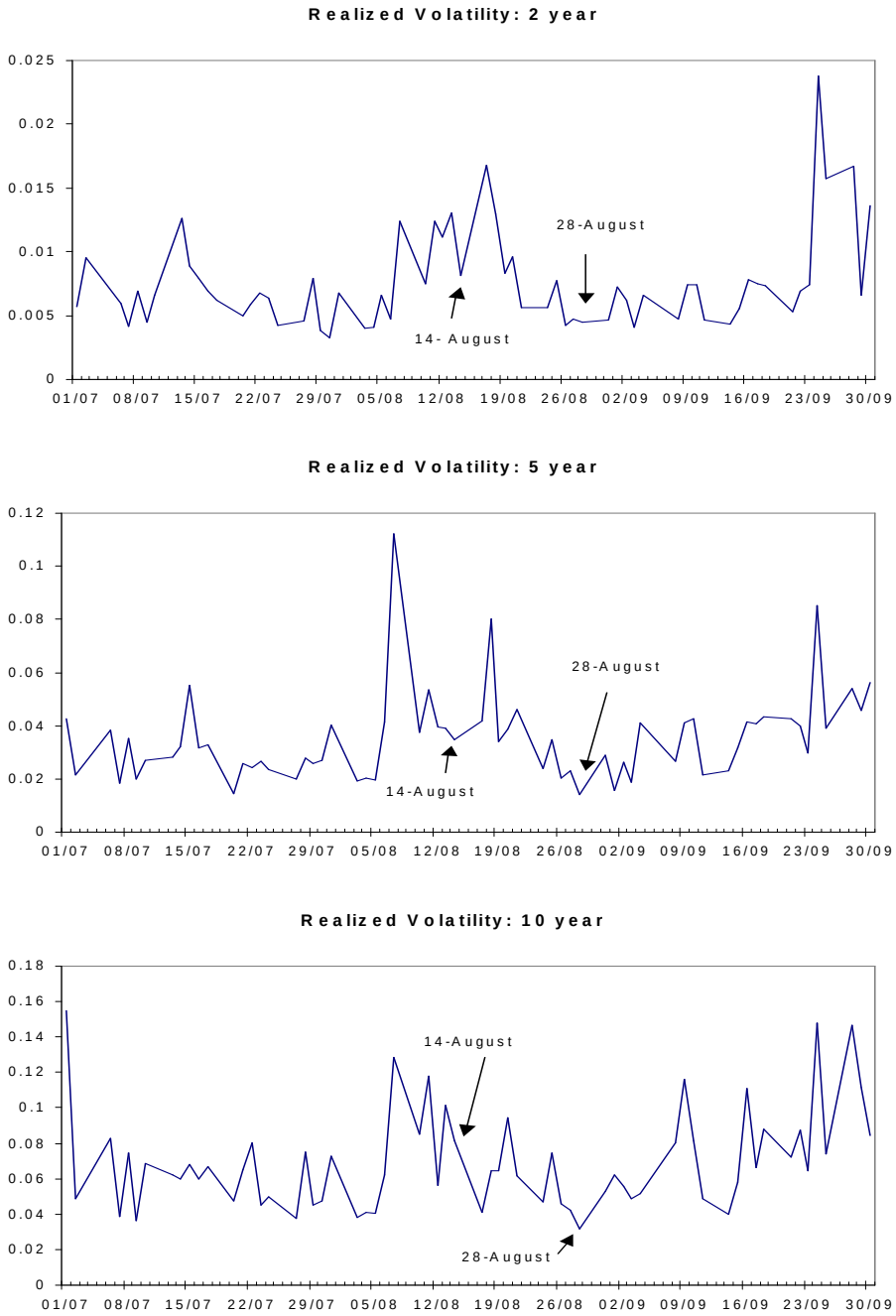

Figure 5: Realized Volatility across maturities.

Figure 5 shows daily realized volatility figures compiled from the 5 minute data for each of the 2, 5 and 10 year maturities for the third quarter of 1998.[13]

[13]The realized volatility of returns over the period is constructed as the sum of the

Notably the realized volatility shows a general decline in all maturities across the fortnight from 14 to 28 August, having peaked in the lead up to this period. In the existing literature, realized returns volatility dynamics can be decomposed into a permanent and transient component, the latter comprising volume volatility; see Hasbrouck and Seppi (2001). A tentative implication of the volume characteristics reported in Section 3.1 coupled with the volatility profile observed here would be that market depth was quite stable. This is an avenue for future research.

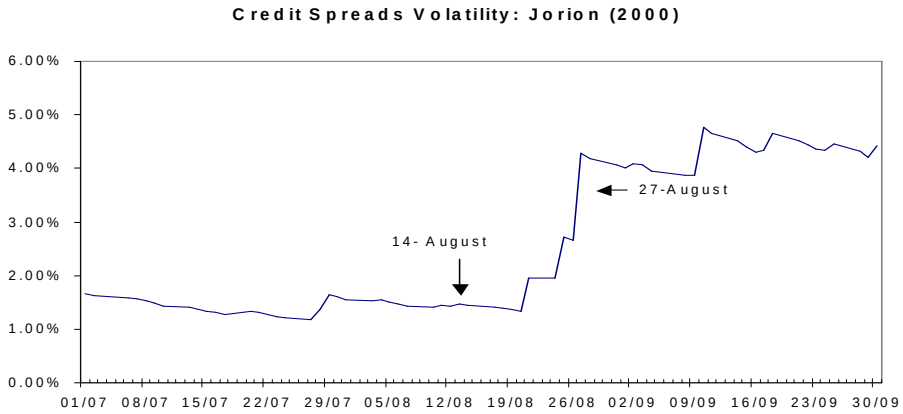

Figure 6: Credit Spread Volatility.

Other evidence on volatility during this period is documented in Jorion (2000) who provides a figure on the volatility of credit spreads based on the commonly used RiskMetrics system. He particularly notest that "volatility creeps up on 25 August...on 27 August, it moves and stays above 0.04, double its recent value." (Jorion 2000: p.288). The pertinent subperiod from Jorion's data is shown in Figure 6.

Another instructive metric in this case is that of realized covariance, constructed as the daily sum of the cross returns between the assets of different

squared five minute returns, having controlled for intraday seasonality using a Flexible Fourier Transform following the 6th order polynomial suggested in Bollerslev, Cai and Song (2000) with day-of-the-week, end-month and macroeconomic news effects included for the impact of the employment situation, CPI and retail sales as detailed in footnote 10. The resulting returns profiles (available from the first author on request) contain the usual volatility smile during the period between New York opening and about 3 pm, similar to that reported in Bollerslev, Cai and Song (2000) for the Treasury futures market. Realized volatility without seasonal factors calculated by simply squaring daily returns as for example used in Hyung, Poon and Granger (2005) show a similar pattern to that presented in the text.

maturities. Figure 7 shows that the realized covariances between each of the 2, 5 and 10 year maturities are relatively unchanged in the period prior to the 27 August, and jump enormously on that date in each of the cases. There is in each case also a smaller increase on the 21 August.

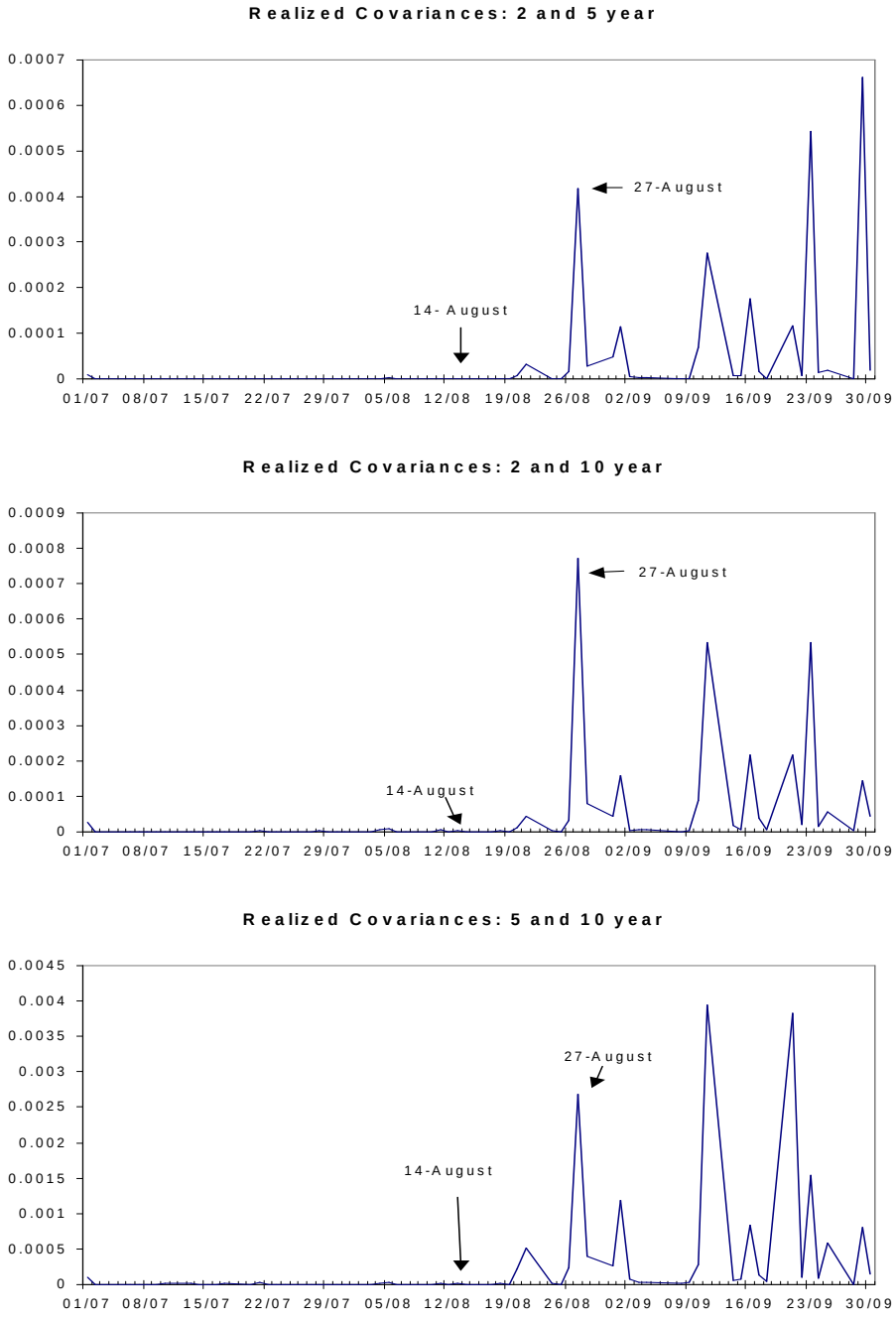

Figure 7: Realized Covariances across maturities.

3.4 Bid-Ask Spreads

The bid-ask spread on US Treasuries may well be the most useful measure of liquidity available in the GovPX inter-broker market at this time.[14] Of a range of liquidity measures, this spread most frequently reacts in the anticipated manner during various interludes of poor liquidity; see Fleming (2003). The spread is the difference between the posted bid and ask prices, with the transaction initiator also paying usually 1/256th on each transaction as brokerage fee. The one-sided nature of the fee, only paid by the dealer responding to the posted quote, may encourage active participation in submitting quotes as a means of reducing costs; see Green (2004).

The bid-ask spread in the US Treasury interbroker market is usually relatively stable for each maturity. Looking at intraday data clearly shows that the "standard" 2 and 5 year maturity transactions had a bid-ask spread of 1/128th of a percentage point in the non-crisis subperiod. The "standard" 10 year contract is slightly more diverse between a 1/64th and 1/32nd spread. The spread widens during the crisis. What is interesting is the timing and composition of this rise. Table 4 shows the average spread and standard deviation for the periods picked out in the previous analysis, expressed in decimal form. Although a discernible increase in spread is observable for each maturity as time goes on, these differences are not statistically significant.

[14] Amihud and Mendelson (1991) demonstrate that there are liquidity effects in pricing US Treasury notes. Chordia, Sarkar and Subrahmanyam (2005) show that adjusting for the Russian crisis removes a potential structural shift in the 10 year Treasuries bid-ask spread. They also report that market depth is lower during crisis periods. Fleming (2003) notes increases in the spread during the 1998 crisis period. Smith and Tambakis (2004) investigate the spread between the on-the-run and first-off-the-run Treasuries of the same maturity looking for breaks, but the break points they find do not correspond to the third quarter of 1998.

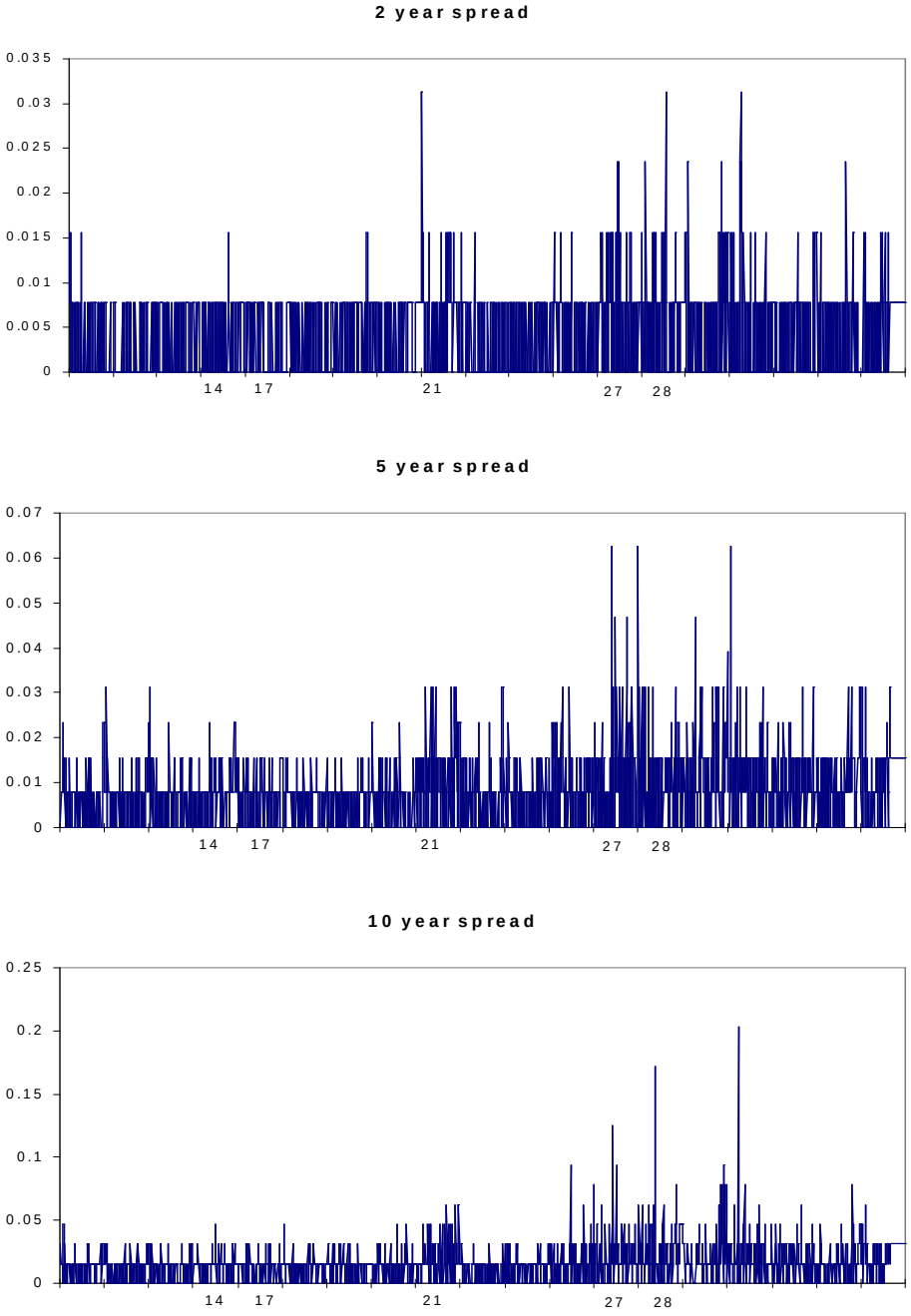

Figure 8: Bid-Ask spread for different maturities of US Treasuries.

Figure 8 shows intraday plots of spreads in each maturity.[15] From 27 August, the incidence of higher spreads is very pronounced. In Table 5 this

[15] A few incidents of negative spreads have been trimmed from the database.

is shown by giving the ratio of 5 minute intervals with spreads at the next most frequent (higher) spread to the number of 5 minute intervals with the "standard" spread. So for example, for the 2 year maturity shown in the top panel of Table 5 the ratio of observations with spreads of 1/64th compared with the "standard" of 1/128th rises from roughly 1 in 10 in the pre-crisis period to 2 in 5 from the 27 August onwards. The rising ratio of greater spreads is common across maturities and is particularly evident from 27 August. After 27 August, there is no evident increase in prominence of larger spreads.

The spreads did not noticeably rise in conjunction with either the initial Hong Kong intervention (August 14), or the Russian default announcement (August 17) or any of the following revelations about the proposals to alleviate it. The spreads then rose perceptibly by the time of the Hang Seng futures contract expiry, and *the majority of the sustained rise occurs on 27 August*, the US trading day associated with the failed double play.[16] Although Lowenstein documents 31 August - the Monday after the expiration of the Hang Seng futures contract - as the date on which the Hong Kong Monetary Authority stopped intervening, traders already knew the game was over during Asian trade on 28 August, when the contract expired. The HKMA had been very clear that they were intervening to stop the double play (see Yam (1998) for example), so the rise in spreads in NY trade time on 27 August is consistent with role of the failure of the speculators' double play in affecting the market.

4 Reconciling Evidence and Events

The empirical findings from Section 3 are now placed in the context of events in the second half of August 1998. Table 6 provides a related chronology for the period and the amount of daily intervention undertaken by the HKMA, estimated by Goodhart and Dai (2003: Table 3.16 p96). The key events in Russia are the announcement of debt suspension and subsequent statements on the GKO market. In all probability, the HKMA sold substantial amounts

[16]Note that there was also a rise in spreads around 21 August which was not sustained.

Table 4:
Average spread observed (decimalised).

Maturity		1 July to 13 Aug	14 Aug to 27 Aug	28 Aug to 30 Sep
2 year	mean	0.002711	0.003856	0.004865
	std dev	0.003941	0.004520	0.006629
5 year	mean	0.005543	0.007146	0.010367
	std dev	0.005698	0.006487	0.012131
10 year	mean	0.012302	0.013088	0.018035
	std dev	0.010180	0.011886	0.0236909

Table 5:
Ratio of 5 minute intervals with a larger observed spread to number of 5 minute intervals with standard observed spread.

ratio	1 July to 20 Aug	21 Aug to 27 Aug	28 Aug to 30 Sep
2 year maturity, standard spread is 1/128th			
1/64th: 1/128th	0.10	0.21	0.40
>1/64th: 1/128th	0.03	0.02	0.12
5 year maturity, standard spread is 1/128th			
1/64th: 1/128th	0.43	0.69	1.14
>1/64th: 1/128th	0.20	0.24	0.63
10 year maturity, standard spread is 1/64th			
1/32nd:1/64th	0.20	0.20	0.56
>1/32nd:1/64th	0.07	0.11	0.44

Table 6:

Timeline of events

	Russia	Hong Kong	
Aug	event	event	intervention* $HKbil
13	Soros letter in FT		
14		initial intervention	3.5
17	debt moratorium	public holiday	
	rouble floats	Yam letter in FT	2.2
18			
19	defaults on GKO payments		2.6
20			1.7
21			1.4
23	Kiriyenko's Govt dismissed		
24			7.1
25	announcement on GKOs		3.5
26	announcement on GKOs		5.3
27			19.4
28	announcement on GKOs	expiration of futures contract	72.1

* Figures from Goodhart and Dai (2003).

of US Treasuries to fund its intervention. Just how this amount of Treasuries might have been released to the market is not clear. However, the empirical analysis of Section 3 provides some clues supporting the hypothesis that the HKMA interventions played a crucial role in the US Treasury market during this period.

- **Sovereign spreads**

Spreads between long-dated US dollar denominated emerging market sovereign debt and the corresponding 10 year Treasury bond rose from 14 to 28 August and then stabilised; see Figures 1 and 2. The Russian bond default of 17 August resulted in a substantial reduction in the price of emerging market sovereign debt. If all the news on Russia had been incorporated into

the default announcement the data should have revealed a once off (permanent) jump in these spreads. Instead, the spread steadily widened over the period to 28 August, and then settled to a new level which is maintained for the remainder of that year (see also Dungey, Fry, Gonzalez-Hermosillo and Martin (2005)). Hence there were other important drivers in the market between 17 and 28 August. While it is possible that further information on deterioration in the Russian banking system contributed to this widening, the evidence suggests that most new information appeared after the period examined here. The possibility that the HKMA intervention impacted the spread through the US Treasury market seems better supported by the data.

- **Traded volume**

The volume of US Treasuries traded increased after 14 and 17 August, and peaked on 27 and 28 August, the last two days of the HKMA intervention. The volume data suggests a strong response in the traded volume of Treasuries to the expiration of the Hang Seng futures contract around which the double play speculation was based. Traded volume was relatively low following the Russian default.

- **Net order flow**

A flight to quality should be associated with strong positive net purchases. Instead, the net order flow data shows net sales in the 5 and 10 year maturities immediately following the Russian default (particularly on 18 August). At the shorter end, particularly 3 month bills, positive net purchases were observed. These data are probably most consistent with a flight to cash in conjunction with a flight to quality. However, on 27 August (the last trading day prior to the expiration of the Hang Seng futures contract) net order flow shows strong net sales in all maturities. This points more clearly to the potential role of the HKMA in making sales in the market. The HKMA is estimated to have spent almost $HK90 billion on intervention on 27 and 28 of August. From 30 of August to the end of the quarter net purchases tend to be positive, with extremely high variance (not shown in the Figures).

- **Realized volatility**

Realized volatility declined in the period from 14 to 28 August from the highest level for the quarter achieved just prior to this fortnight. Other literature suggests that the combination of the returns profile and the volume profile observed may be consistent with quite stable market depth over the period; Hasbrouck and Seppi (2001). This is an avenue for future research.

- **Bid-ask spreads**

Bid-ask spreads in US Treasuries remained at usual levels for most of August, and widened only around 27 August. During periods of low liquidity the bid-ask spread in the Treasury market is known to rise; see Fleming (2003). In the period under examination, this rise did not occur in a sustained manner until 27 August, consistent with the US trading day prior to the expiration of the Hang Seng futures contract. Although spreads widened around 21 August for several maturities, this was short-lived. Between 14 and 27 August both the Russian default and the HKMA intervention were potentially affecting the US Treasury market. After 27 August the HKMA ceased intervention in US trading time. The bid-ask spreads' behaviour suggests that liquidity was significantly affected by the HKMA supplying Treasuries to the market.[17]

The reconciliation of the empirical evidence with the events of the fortnight of 14 to 28 August strongly suggest that the actions of the HKMA in intervening in the Hong Kong stock market, funded at least in part by sales of US Treasuries, had a dominant role to play in determining outcomes in the US Treasuries market during this period. The Russian default was an important influence, but for this fortnight in August, the HKMA intervention seems to have had a much greater impact.

[17] In contrast to the US Treasuries market, the bund bid-ask spread also rose discernibly and realized volatility was higher for the next several weeks than it had been prior to the announcement of the Russian debt suspension, see Upper (2001) and Upper and Werner (2002).

5 Concluding remarks

The third quarter of 1998 was the first time in recent history that bond markets experienced substantial volatility, more akin to that associated with currency market crises. The period was marked by important international events; combined pre-emptive interventions in both the Hong Kong equity markets to stave off further speculative attacks on the Hong Kong currency market and economy, and the subsequent speculative pressure in Hong Kong markets up to the date of settlement of the Hang Seng futures contract on 28 August, on which the so-called double play in Hong Kong markets was based. On 17 August the Russian Government suspended payments on its sovereign debt, with details worked out in the ensuing months.

Although much of the literature on the 1998 crisis focuses on the Russian default as the springboard for the ensuing turmoil in international debt markets, we demonstrate through careful examination of high-frequency data that the Hong Kong interventions had a crucial role to play. The US Treasury market played an important role in transmitting and absorbing the effects of the seemingly unrelated financial market shocks of the Russian bond default and the interventions associated with the Hong Kong speculative double play.

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