Working Paper

INTERNATIONAL MONETARY FUND

WP/05/34

IMF Working Paper

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Research Department and Monetary and Financial Systems Department

Were Bid-Ask Spreads in the Foreign Exchange Market Excessive During the Asian Crisis?

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February 2005

Abstract

Bid-ask spreads for Asian emerging market currencies increased sharply during the Asian crisis. A key question is whether such wide spreads were excessive or explained by models of bid-ask spreads. Precrisis estimates of standard models show that spreads during the crisis were in most cases tighter than spreads predicted by the models and there are few cases of excessive spreads. The result is largely explained by the substantial increase in exchange rate volatility during the crisis and to some extent by the level change. The empirical models have greater explanatory power for emerging- than for mature-market currencies.

JEL Classification Numbers: F31, G14, G15

Keywords: Foreign exchange, market microstructure, bid-ask spreads, Asian crisis

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[1] The authors thank Philippe Jorion, Donald Mathieson, Anthony Richards, and seminar participants at the IMF and at Thammasat University for their comments and suggestions. Special thanks to Bankim Chadha for the idea and Peter Tran for his assistance with the data.

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I. Introduction

Bid-ask spreads in foreign exchange markets are important since they determine transactions and hedging costs, which in turn affect trade, the effectiveness of policy, and ultimately carry significant real costs to the economy.[2] The study of bid-ask spreads and the microstructure of foreign exchange markets can also complement traditional exchange rate models' analysis of short-run exchange rate behavior, which is an area where the conventional macro models have had limited success.[3] Market microstructure issues are particularly important in times of balance of payments crises when the adjustment process of the economy critically depends on exchange rate movements. Furthermore, if transaction costs increase significantly with a move from a relatively fixed exchange rate to a floating exchange rate, it takes longer before the added flexibility of the exchange rate has a positive effect on the real economy.

Table 1. The Cost of a US$10 Million Round Trip Transaction
(in U.S. dollars)

Currency 1996-97		Crisis
Thai baht	13,100	68,300
Indonesian rupiah	8,800	215,900
Korean won	34,500	42,200
Malaysian ringgit	4,000	28,300
Philippine peso	23,700	163,500
Singapore dollar	6,900	14,000
Hong Kong dollar	1,200	1,400
Japanese yen	6,000	5,700

Sources: Reuters; and authors' calculations

During the Asian crisis, bid-ask spreads on most Asian currencies skyrocketed to levels never seen before. Bid-ask spreads widened by factors of between 5 and 14 in dollar terms, drastically increasing transaction costs for converting emerging market currencies into dollars. Table 1 provides an overview of the costs associated with a US$10 million roundtrip transaction before and during the crisis period for the different Asian currencies that are analyzed in this paper. For example, for the Indonesian rupiah, the cost increased from a moderate US$8,000 precrisis to a cross-section high of US$215,900 during the crisis, whereas for the Hong Kong dollar (which remained under its currency board arrangement) the cost increased by only US$200. Such levels

[2] The European Commission (1990) estimated that the elimination of spreads following the adoption of a single European currency would result in savings of 0.4 percent of Community GDP per annum. Furthermore, the estimated total transaction costs incurred by nonfinancial firms were on average 15 percent of their profits on turnover in other EC countries.

[3] See Flood and Taylor (1996).

and swings in the costs of currency transactions can obviously have a significant impact on both micro- and macroeconomic variables.

Bid-ask spreads also affect the revenue of various institutions active in the foreign exchange markets, including commercial banks. Consequently, the abrupt rise in bid-ask spreads during the Asian crisis resulted in record trading profits for banks. The Institute of International Finance (1999) remarked that "...a diversity of business lines enabled most banks to offset losses in Asia with record foreign exchange trading revenues. This enabled most financial firms to emerge from the East Asian market turmoil without experiencing debilitating losses." One justification for these record profits is that the gains represented compensation for the high levels of risk that had to be incurred during such turbulent times.

The purpose of this paper is to examine if bid-ask spreads on Asian currencies were excessive during the 1997 crisis. In answering this question, the paper first documents features of bid-ask spreads for Asian emerging market currencies and then estimates standard models of bid-ask spreads that have previously been used mainly for mature markets. The currencies studied are the Thai baht (TB), the Indonesian rupiah (RP), the Korean won (W), the Malaysian ringgit (RM), the Philippine peso (PHLP), the Singapore dollar (S$), the Hong Kong dollar (HK$), and as a mature market benchmark, the Japanese yen (Y).

The focus on emerging markets and the Asian crisis distinguishes this paper from most of the literature. One other paper on emerging market currencies is Galati (2000), which studies the Colombian and the Mexican pesos, the Brazilian real, the Indian rupee, the Indonesian rupiah—the only Asian currency that is also included in this paper—and the Israeli sheqel as well as the South African rand in the 1998–1999 period. Similarly, Martin (undated) looks at how bid-ask spreads for various currencies around the world change during the Asian crisis, but does not compare crisis spreads with predicted spreads or address the question of excess spreads.

The main conclusions of this paper are, first, that many regularities observed for bid-ask spreads of mature market currencies are present also for emerging market currencies and the models of bid-ask spreads used for mature markets seems to have greater explanatory power when applied to emerging markets. Secondly, the paper finds that for most currencies and model specifications, there is no evidence of excessive spreads in the crisis period. From a statistical point of view, the sharp increase in both the level and volatility of exchange rates is more than enough to explain the blow out in bid-ask spreads. This could be interpreted as evidence that the increase in profits of bank's foreign exchange trading was largely compensation for the increased costs (in an economic rather than accounting sense) of trading.

II. Overview of the Literature

A standard measure of transaction costs in asset markets is bid-ask spreads. Market microstructure theory decomposes transactions costs into three different types of costs: (1) order processing costs; (2) asymmetric information costs and (3) inventory-carrying costs. Order processing costs are negligible in the foreign exchange market given the efficiency with which transactions are completed and their size. Asymmetric information costs are based on the presence of information-motivated traders. One way for uninformed traders to protect against informative incoming order flow is to increase the bid-ask spreads, thereby including an adverse selection component in the spread.[4] Unfortunately, order flow data during the Asian crisis for emerging market currencies is difficult to obtain. Inventory carrying costs arise because market makers maintain open positions in foreign currencies which expose them to market risk and carrying costs in terms of interest rate differentials and trading activity. The notion of a desired inventory level for market makers underlies all of the theoretical models relating bid-ask spreads and inventory-carrying costs.[5] This paper will focus on inventory-carrying costs in explaining and forecasting spreads in the interbank foreign exchange market for the Asian currencies discussed above.

Market risk is the most prominent factor in explaining changes in bid-ask spreads in the literature. Greater uncertainty regarding the spot rate is likely to result in a widening of the spread as risk-averse traders increase the spread to offset the increased risk of losses. The uncertainty regarding future spot rates have been proxied both by the variance generated by GARCH models of the exchange rate and by options-implied volatility. For both types of measures, it has been shown that bid-ask spreads depend positively on volatility.[6] Furthermore, market uncertainty is reportedly the most important reason for deviating from conventional interbank bid-ask spreads.[7]

The interest cost of holding a (liquid) currency inventory arise when a market-maker foregoes the interest rate that can be earned on less liquid instruments. The alternative to maintaining liquid currency inventories is to respond to buy and sell orders by settling transactions at another bank's ask price or bid price, effectively paying the bid-ask spreads on its settling transactions. Consequently, earning a spread on transactions associated with order imbalances requires that the bank be a net supplier of liquidity to other traders. A measure of the opportunity cost resulting from the requirement to maintain liquid inventories is the difference between the interest rate earned on a highly liquid position and the interest that could have been

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[4] Empirical studies typically use order flow data to find evidence of an adverse selection effect in mature market currencies. See Lyons (2001) for a review, Peiers (1997) for an analysis of price leadership for the Deutsch mark, Covrig and Melvin (2002) on asymmetric information in the yen market and Evans and Lyons (2004) for a micro model of exchange rates.

[5] See the dynamic optimization models of Bradfield (1979), Amihud and Mendelson (1980) and Ho and Stoll (1981).

[6] See Glassman (1987), Boothe (1988), Bollerslev and Domowitz (1993), Bollerslev and Melvin (1994), Lee (1994), He and Wei (1994), and Jorion (1995).

[7] Cheung and Wong (1999) surveyed individual traders in the interbank market and concluded that practitioners generally follow the market convention to set their interbank bid-ask spreads, consistent with the empirical clustering of spreads. The practice is perceived as a means to maintain an equitable and reciprocal trading relationship between dealers. However, market uncertainty in the form of a hectic market, increased market volatility, major news releases, and unexpected changes in market activity were the major reasons for deviating from the market convention.

earned on similar but less liquid positions. Typically the interest rate cost is measured as the difference between short and long interest rates.

The third component of inventory-carrying costs involves trading activity. There is evidence that spreads tend to increase when markets are less active as before the weekend and holidays. For example, Glassman (1987) finds that bid-ask spreads widen on Fridays and Bessembinder (1994) finds that measures of liquidity cost and risk variable are more pronounced before non-trading intervals. Trading activity is also measured by trading volume and many authors have documented the positive correlation of bid-ask spreads with volume. Cornell (1978) argues that spreads should be a decreasing function of expected volume because of economies of scale and competition among market makers. The theoretical model of Easley and O'Hara (1992) reaches a similar conclusion. Unexpected volume, however, reflects contemporaneous volatility through the mixture of distribution hypothesis and should be positively related to bid-ask spreads. Hartmann (1999) provides empirical support for the theories, but Galati (2000) does not find evidence of a significant impact of unexpected trading volume on spreads for emerging market currencies. In many cases, volume data are not available. However, Boothe (1988) shows that although estimators are less efficient and potentially inconsistent if volume is omitted, the direction of potential coefficient bias is such that hypothesis tests regarding the importance of exchange rate uncertainty are rendered more conservative.

III. DATA

The exchange rate data come from Reuters and are indicative interbank bid and ask quotes averaged across several banks at a specific time each day. The currencies studied are the Thai baht (TB), the Indonesian rupiah (RP), the Korean won (W), the Malaysian ringgit (RM), the Philippine peso (PHLP), the Singapore dollar (S$), the Hong Kong dollar (HK$), and the Japanese yen (Y). In general, daily data covering the period 1/1/1990 to 11/2/1998 are used, although in some cases data are available for a somewhat shorter period.[8]

The five first currencies (TB, RP, W, RM, PHLP) were relatively fixed in the early part of the sample but were floated (at least temporarily) at the beginning of the Asian crisis.[9] The S$ was relatively flexible (although managed without announced bands by the Monetary Authority) while the HK$ was under a currency board regime during the entire sample period. The Y is included in this study as a reference to a major mature market currency with Asian origin.

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[8] More specifically, data for TB starts 5/6/91, for RP 11/19/90, for W 5/30/90 and for PHLP 5/18/92.

[9] The Thai baht was floated in July of 1997 as was the Philippine peso and the Malaysian ringgit. The Indonesian rupiah was floated in August and the Korean won in November. The Singapore dollar and the Japanese yen also depreciated during the Asian crisis, while the Hong Kong dollar remained under a currency board regime despite pressure that was particularly severe in late October. See Box 2.12 in International Monetary Fund (1998) for a chronology of the Asian crisis.

The theoretical literature that focuses on inventory carrying costs as determinants of bid-ask spreads suggests that empirical models of spreads should include variables that measure market risk and the costs of carrying a liquid inventory and trading. In practice this translates into using measures of exchange rate volatility (with a positive sign), interest rate differentials between short and long instruments (+), expected (-) and unexpected (+) trading volume, and dummies for weekdays and time. These measures and key characteristics of the data will be discussed in the remainder of the section.

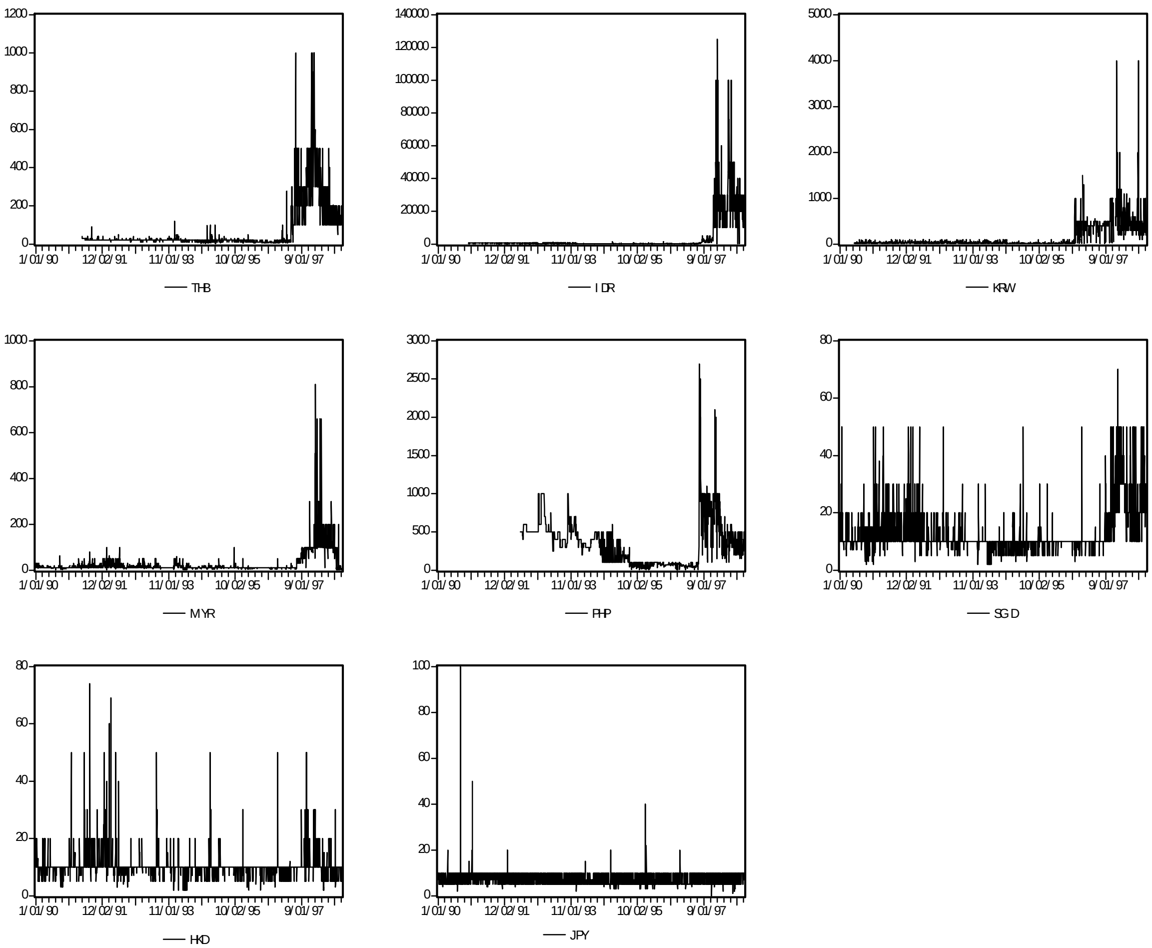
Bid-Ask Spreads

Figure 1 and Table 2 show the massive increases in bid-ask spreads that motivate this paper. The figure uses daily absolute spreads since 1990 while the table contains the mean and maximum values of absolute and percentage spreads. A closer look at the distribution (see Appendix table) shows that the clustering of bid-ask spreads observed in mature markets is evident also in these emerging markets.[10] The most common spread accounts for anywhere between 18 to 84 percent of the observations before the crisis (with a cross-country average of 53 percent), while the cumulative frequency of the 3 most common spreads range from 40 to over 90 percent (80 percent). The strong clustering observed in relatively calm times is reduced during the crisis period. This is not surprising given the substantial increase in uncertainty and level change of the exchange rates and is consistent with the findings in Cheung and Wong (1999). The cross-country average is down to 36 percent for the most common observation and 70 percent for the three most common spreads during the crisis. Excluding HK$ and Y the reduced clustering in the crisis period becomes even more evident.

Although absolute spreads are not suitable for comparison between countries or over time when exchange rates change dramatically, it is still of some interest to note that for the first five currencies the average absolute spread increase by a factor of around 10 in the crisis period. For the rupiah, the increase is around 60 times, while for the peso only around twice. The peso, however, had experience a steady decline in spreads in the years before the crisis, and if compared with only the year before the crisis, the mean spread increased by almost a factor 10 in the crisis, comparable with the other countries.

[10] The clustering occurs when the exchange rates are stated in the European way, that is, home currency per U.S. dollar, which is the conventional way of quoting these currencies. See Bessembinder (1994) and Bollerslev and Melvin (1994) for clustering in mature markets.

Figure 1. Interbank Bid-Ask Spreads



Percentage spreads are more relevant when comparing transactions costs between countries and over time, since it takes into account the level of the exchange rate (or put differently, it converts local currency spreads to dollars). It became substantially more expensive to get in and out of all of the emerging market currencies (except the HK$) during the crisis period. For some currencies (RP, RM, PHLP), the year ahead of the crisis had been a year of declining spreads as their markets became more developed. For Thailand and especially Korea, the trend was towards greater spreads, and could perhaps be explained by a build up of uncertainty regarding these exchange rates well ahead of the actual float.

Table 2. Precrisis and Crisis Spreads

Currency	Precrisis				Crisis			
	Absolute spreads [a]		Percentage spreads [b]		Absolute spreads		Percentage spreads	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max
TB	21.9	300	0.087	2.062	274	1000	0.683	3.390
RP	329	1500	0.159	0.672	20734	125000	2.159	9.524
W	62	1500	0.075	1.765	522	4000	0.422	2.996
RM	14	100	0.052	0.398	105	810	0.283	1.841
PHLP	278	1000	1.062	4.040	595	2700	1.635	9.168
S$	11	50	0.071	0.358	23	70	0.140	0.394
HK$	10	74	0.013	0.095	10	50	0.014	0.065
Y	7	100	0.062	0.682	7	10	0.057	0.089

[a]The absolute spreads have been scaled to make the smallest absolute spread observed an integer, so TB is multiplied by 1000, RP by 100, W by 100, RM by 10000, PHLP by 1000, S$ by 10000, HK$ by 10000, and Y by 100.
[b] Percentage spreads are unscaled absolute spreads divided by the midpoint of the exchange rate.

Looking across the different countries in the region, the spreads in HK$, which operates under a currency board, were extremely small compared not only to the emerging market currencies but also to the yen. At the other end of the spectrum were the RP and PHLP during the crisis period where percentage spreads were more than 100 times the spreads in the HK$. After the HK$, the RM had the smallest spreads among the emerging markets, both before and after the crisis, and even smaller than Y in the pre-crisis period. The PHLP experienced the most significant reduction of spreads leading up to the crisis, with percentage spreads down to 0.23 in the year before the crisis compared to 1.06 percent for the entire pre-crisis period. In the crisis, however, spreads came back up to levels well above the pre-crisis mean.

As a first cursory investigation of the relationship between spreads and exchange rate volatility, Table 3 presents the ratio of spreads to exchange rate volatility, measured as the standard deviation of exchange rate returns (i.e., the first difference of the logarithm of the exchange rate)[11]. The most obvious observation is that volatility increased for all of the currencies in the crisis period, with a factor of anything between marginal increases to forty fold increases.

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[11] The returns are used to compute the volatility measure since in general, a unit root in the level exchange rate series cannot be rejected at normal significance levels. Hong Kong SAR is the only case where the null of a unit root can be rejected, but the same volatility measure is used for comparability.

Dividing absolute and percentage spreads with volatility seems to “explain” a fair amount of the spread explosion in the crisis period in the sense that these ratios are not higher in the crisis period than in other periods. Instead, volatility adjusted percentage spreads are in all cases except for TB lower in the crisis period compared with earlier periods. For RP this is not the case when absolute spreads are used in the numerator, due to the substantial depreciation of the currency, although for the other currencies the fall in the ratio is observed also for the absolute spread to volatility ratio.

Table 3. Exchange Rate Volatility and Spreads

	Pre crisis	96/97	Crisis	Full sample
Volatility[a]				
TB	36.46 87.3	7	197.1 89.6	2
RP	11.61 14.1	0	485.7 19.9	6
W	17.19 26.8	6	255.4 102.	9
RM	20.80 16.6	3	165.8 67.3	9
PHLP	38.46 4.51 143.		3	73.75
S$	23.51 15.8	0	79.87 37.9	0
HK$	3.45 1.71		3.97 3.53	
Y	68.33 62.8	4	98.28 73.6	3
AS/Volatility				
TB 6.0		3.8	13.9	7.5
RP	2836.4 1478	.0	4269.4 1882	.9
W 361.	8	1108.7	204.5	128.2
RM	0.65 0.61		0.64 0.41	
PHLP 72.5		137.9	41.5	46.7
S$	0.48 0.62		0.29 0.34	
HK$	2.97 5.47		2.72 2.92	
Y 10.6		11.0	7.4	9.8
PS/Volatility				
TB	0.238 0.14	9	0.346 0.21	5
RP	1.365 0.62	3	0.445 0.24	8
W	0.436 1.28	4	0.166 0.12	4
RM	0.248 0.24	3	0.171 0.12	9
PHLP	2.762 5.24	4	1.141 1.60	2
S$	0.300 0.43	5	0.176 0.21	4
HK$	0.383 0.70	6	0.351 0.37	8
Y	0.091 0.09	6	0.058 0.08	3

[a]Volatility is measured as the standard deviation of the exchange rate return in percent.

Exchange Rate Risk

In Table 3, volatility was measured as the standard deviation over a certain time period. This measure can serve as a first check of the relevance of volatility, but suffers the obvious limitation of being constant over the period it is measured while changes in spreads and exchange rate volatilities occur at high frequency. To produce high frequency measures of the (perceived) exchange rate risk, GARCH models are estimated for the midpoint of each exchange rate, and then used to compute time varying conditional variances for the exchange rates. Following the literature in this area, the estimations are based on first differences of the logarithm of the exchange rate series, which is done to remove the unit root in the original level series[12]. The transformed series has the interpretations of being a one day return on holding the currency. The estimated model used for all exchange rates is a GARCH(1,1) model with dummies for weekdays and floating of the exchange rate in the variance specification (D_i ,D_f)[13]. The dummy for the float is also included in the mean equation. Formally, volatility is measured by the conditional variance obtained from the GARCH(1,1) model

$$\begin{aligned} R_t &= \mu_M + \delta D_f + \varepsilon_t \\ \sigma^2_{R,t} &= \mu_\sigma + \sum_{i=1}^{4} \gamma_i D_i + \gamma_5 D_f + \alpha \varepsilon^2_{t-1} + \beta \sigma^2_{R,t-1} \end{aligned} \quad (1)$$

where $R_t \equiv 1{,}000 \times \Delta \log(M_t)$ and $\varepsilon_t | I_t \sim N(0, \sigma_{t-1}{}^2)$. The conditional variance $\sigma^2_{R,t}$ is the one period ahead forecast of the variance given information at time t-1[14]. The μ's, δ, γ's, α, and β are the parameter to estimate. Table 4 presents the mean of the estimated conditional variances. The average numbers are in line with the standard deviations in Table 3, and provide little

[12] Simple augmented Dickey-Fuller and Philips-Peron tests of the level data confirm that the null of a unit root cannot be rejected for 7 of the 8 series. For the HK$, the null can be marginally rejected, however, the first difference of the log series is still used to conform to the estimation for the other countries. Furthermore, as a test, GARCH in levels were also estimated and the resulting conditional variance series was perfectly (to the third decimal) correlated with the series from the first difference GARCH.
[13] Since the specification test of the standardized residuals sometimes suggested that the model needed to be extended to include MA or AR components in the mean, these more elaborated models were also estimated and the resulting conditional variance series were compared to the ones obtained by the basic GARCH(1,1). In all the cases, the correlation between the series were between .99 and 1, and to maintain as much comparability as possible, the basic model was used in the remainder of the investigation.
[14] In Bessembinder (1994), the author includes the conditional variance *led* one period in the spread equation (see p. 328), which seems to suggest that the author allows the traders to include information at time t for the forecast for time t. In this paper, time t information about volatility is not assumed to be known for the spread decision at time t. In other words, we use σ^2_t rather than σ^2_{t+1} as the volatility forecast in the spread equation.

additional information about the level of exchange rate uncertainty, but the GARCH model also produces a daily series of changing conditional variances which is used in the estimations below.

Table 4. Average Conditional Variances

	Pre-crisis	96/97	Crisis	Full sample
TB	10.9	59.9	441.6	87.8
RP	1.57	2.01	2583.4	435.8
W	3.7	8.1	701.1	114.2
RM	4.7	3.4	276.9	45.9
PHLP	21	4.1	255.8	69.6
S$	5.8	3.5	69.2	15.4
HK$	0.15	0.04	0.28	0.17
Y	46.9	40	96.5	54.4

Volume Measures

Measures of expected and unexpected volume are problematic for several reasons. First, there is, to our knowledge, no publicly available *daily* volume data for emerging markets foreign exchange transactions. Furthermore, even if such data were available, the issue of simultaneity between spreads and volume would have to be addressed. In this study, we use daily volume data in the stock market as an instrument for the volume in the interbank market. The reason that stock market volumes are used is that we postulate that some of the foreign exchange trade is motivated by transactions in the local stock markets that investors want to convert into different currencies. We have, however, repeated our analysis using monthly transaction volume data for the Malaysian ringitt. The general result that bid-ask spreads to a large extent can be explained by exchange rate risk is reinforced when currency transaction volume data are added.

The next issue that arises irrespective of the series used is how it should be decomposed into an expected and an unexpected component. In other studies this has been achieved by fitting univariate ARIMA models to the levels or differences, and let the predicted value represent the expected volumes and the residuals be the unexpected component.

The strategy employed here is to fit the smallest possible ARIMA model that passes the standard residual test, but in the case there are indications of ARCH effects, these are included in the estimation process and thus a slightly more general model is used for the volume decomposition. Since ADF tests of all the series rejected the null of a unit root in the series, the ARMA model for the means are based on the series in levels. In general, the series could be well described by the ARMA(2,1)-GARCH(1,1) model according to

$$\begin{aligned} V_t &= \beta_0 + \beta_1 V_{t-1} + \beta_2 V_{t-2} + \varepsilon_t - \theta \varepsilon_{t-1} \\ \sigma^2_{V,t} &= \alpha_0 + \alpha_1 \varepsilon^2_{t-1} + \alpha_2 \sigma^2_{V,t-1} \end{aligned} \quad (2)$$

Using a ARMA-GARCH model also allows us to use an alternative measure of the uncertainty regarding volumes, namely the conditional variance of the residual, rather than the residual itself. This is potentially a more appealing measure of the uncertainty in volume compared to using a single residual to measure the uncertainty in volumes, since it is based on more information and has a natural forward looking property making it suitable for forecasting the uncertainty, not only notice it when it has happened, which is the case when the residual itself is used.

Measures of Interest Rate Differentials

In the literature it is argued that an interest rate differential should enter the analysis of spreads to account for the alternative cost of performing the service of creating liquidity in the foreign exchange market and thus forego a more attractive alternative use of funds. The measure used by Bessembinder (1994) is the interest differential between overnight deposit rates (short position) and one month deposit rates (long position) in the Eurodollar market, the motivation being that the longer maturity return is foregone and only the shorter maturity return is received for the stock of foreign exchange. To make this a cost in a narrow business/accounting sense, we have to (at least) make the assumption that the long rate is always higher than the short, which is already a restrictive assumption that clearly is incorrect in certain periods. More importantly is that from an economic perspective this is a measure that hinges on the preferred investment horizon, what is perceived as the natural alternative to holding foreign exchange, such as for instance the domestic currency. In the current study, four interest differentials have been used in the empirical models (to the extent data are available), first the standard Eurodollar short-long differential, secondly the domestic currency short-long differential, and finally the differential between foreign and domestic rates, both for short and long maturities.

IV. Estimation

A. What Explains FX Bid-Ask Spreads in Emerging Markets?

Three different measures can be used for the dependent variable “spread”: the absolute spread, the percentage spread or grouping absolute spreads into a relatively small set of classes, for example "small, medium and large" spreads. The most straightforward measure is the absolute spread itself, defined as $AS_t \equiv A_t - B_t$, where A_t is the ask and B_t is the bid price. However, this measure has some problems since the spread could be a function of the level of the exchange rate, which motivates normalizing the absolute spread by dividing by the midpoint of the exchange rate and thus create a percentage spread measure, defined as $PS_t \equiv AS_t / M_t$ with $M_t \equiv (A_t + B_t)/2$. On the other hand, if exchange rate variations are not very large and we concentrate the attention on a single market, using percentage spreads may actually hide some regularities in the data. Absolute spreads are often clustered around certain values, like 5, 10 or

25 basis points, which is also the case for the currencies analyzed in this paper. Therefore, some researchers have used ordered probit or logit models with the dependent variable reclassified into a relatively small number of categories.

The spread equations were estimated for both absolute and percentage spreads using OLS with Newey-West robust standard errors[15]. These estimations form the basis for the remainder of the paper, while the result of the ordered probit estimation is omitted. The reason for this is that the purpose of the paper is to investigate spreads in a crisis period and in doing so, comparing these spreads to spreads in tranquil times. Ordered probit models then run into the problem that the classification of for example "small, medium and large" spreads change between these time periods. In other words, the spreads in the crisis period are generally so large that they have not been observed in the pre-crisis period. Therefore, an ordered probit model with an open last category would put all the crisis observations in this category and there would be no variation to explain in the crisis period. This turned out to be the case for all the emerging market currencies that we are primarily interested in and only for Y does the ordered probit model improve performance in-sample. To conserve space, we do not report or discuss the ordered probit results.

The type of equations that are estimated by using OLS with robust standard errors are of the form

$$S_t = \alpha_0 + \alpha_1 S_{t-1} + \alpha_2 \sigma^2_{R,t} + \alpha_3 \Delta i_t + \alpha_4 V_{t-3} + \alpha_5 \sigma^2_{V,t} + \sum_{i=1}^{3} \alpha_{i+5} D_{i,t} + \alpha_9 T + \eta_t \quad (3)$$

where the dependent spread variable S_t is either the absolute or the percentage spread. The $\alpha' s$ are the coefficients to be estimated, $\sigma^2_{R,t}$ is the conditional variance from equation (1), Δi_t is the alternative cost, V_{t-3} is the proxy for expected volume, $\sigma^2_{V,t}$ is the proxy for unexpected volume from equation (2), $D_{i,t}$ are the dummies for weekdays, T is a time trend, and η_t is the error term. The volume variable is lagged three days to allow for a normal settlement lag in the stock market, that is, the stock market transaction is assumed to be translated into an FX transaction only after it is settled. The time trend is included to allow for the fact that some financial markets develop over time, which could influence the spreads.

Three sets of explanatory variables are used. In the first set, only the constant and the conditional variance explain spreads. The second regression model adds the lagged spread, and the third model adds all the other right hand side variables in equation (3). The dependent variable is either absolute spreads or percentage spreads giving rise to a total of six specifications. The models are then estimated for each of the eight countries for the full sample, the pre-crisis period and the crisis period. This give rise to a very large number of parameter

[15] OLS with robust standard errors are equivalent to the GMM estimation employed by Bessembinder (1994).

estimates. Table 5 displays the full sample estimates from the specification that use percentage spread as the dependent variable and include all the independent variables from equation (3) while the details of the other estimates are reported in the Appendix table.

Table 5. Estimates of Bid-Ask Spread Equations for Asian Currencies

	TB	RP	W	RM	PHLP	S$	HK$	Y
Dependent variable: PS_t								
Independent variables:								
Constant	-254.77	-216.92	-3.64	-418.06 81	4.26 22	0.38 10	5.20	7.29
	-3.84	*-2.94*	*-2.09*	*-2.75*	*3.02*	*3.27*	*12.32*	*22.67*
$\sigma^2_{R,t}$	0.21 0.	02 0.	01 3.	03 1.	62 3.	23	60.29 0.	01
	2.69	*2.36*	*1.35*	*3.32*	*3.77*	*2.64*	*3.26*	*5.65*
PS_{t-1}	1.21 0.	00 0.	05 6.	82 1.	94	17.04 2.	07 0.	04
	7.16	*2.93*	*7.03*	*3.10*	*8.80*	*5.73*	*3.28*	*1.83*
Δi	21.44 1.	06 1.	51	39.78	-78.35	-21.01 4.	55	-0.49
	0.58	*1.43*	*0.89*	*2.20*	*-1.00*	*-0.53*	*1.45*	*-7.37*
V_{t-3}	0.14 -0	.03 -0	.11 -2	.08 -0	.14	1.99	0.00	0.00
	0.99	*-0.42*	*-2.74*	*-2.53*	*-2.09*	*1.63*	*0.09*	*0.63*
$\sigma^2_{V,t}$	-0.001 0.	002 0.	004 0.	198	-0.002 0.	358 0.	001 0.	000
	-0.73	*1.88*	*0.57*	*2.34*	*-3.08*	*3.30*	*1.20*	*0.02*
Mon	-7.66 -1	1.89	0.14	-3.81 -7	4.29 -5	9.21	-0.69	-0.22
	-0.38	*-1.47*	*0.11*	*-0.07*	*-1.64*	*-2.72*	*-0.21*	*-1.44*
Wed	6.72	6.36 -1	.10	-16.05	19.78	1.48 -1	.82 -0	.13
	0.30	*0.71*	*-1.28*	*-0.29*	*0.31*	*0.08*	*-0.60*	*-0.83*
Fri	18.24 9.	53	-0.41 5.	46	26.68	80.58 8.	68 1.	43
	1.03	*0.89*	*-0.45*	*0.10*	*0.52*	*3.10*	*2.71*	*8.45*
Trend	0.21 0.	13 0.	01 0.	61	-0.33 0.	16	-0.01 0.	00
	5.23	*2.84*	*5.14*	*5.05*	*-2.14*	*4.25*	*-1.61*	*-8.10*
Obs.	1062	591 1	717 1	206	754 1	326 1	322 1	371
$\bar{R}^2$	0.63 0.	69 0.	56 0.	65 0.	73 0.	51 0.	22 0.	14

Note: Estimates for the full sample period. Robust standard errors used to compute *t-statistics*.

The most robust result is that exchange rate risk, measured as the conditional variance of the exchange rate, enters with a positive and statistically significant coefficient in the spread equation in almost all cases. This confirms empirical results obtained for mature market currencies (see, e.g., Bessembinder 1994), and is also in line with the theoretical models.

Another variable that is always positive and often significant is the lagged spread. This result is also consistent with findings in mature markets. In some instances when percentage spreads are used, the coefficients are greater than one, indicating problems with non-stationarity for those specifications.

The interest rate differential that turns out to have a significant effect in most cases is the difference between foreign and domestic rates, while the Eurodollar short-long differential hardly turns up significant in any estimated equation. Irrespective of the measure used, however, the signs are mixed and the coefficients are seldom significant.

Expected volumes seem to add some explanatory power in certain markets but not in others, and the (point estimates of) signs are not always consistent with what the previous considerations would suggest. For RM, the coefficient is negative as predicted by theory, but it is positive for S$. The volatility in volumes should be positive according to theory, and there are a number of cases with significant positive coefficients, but the general impression is more mixed.

Weekday dummies are negative on Mondays in most cases, but only statistically significant in a few cases, while they are positive for Fridays in most cases and statistically significant in many cases for the currencies associated with more developed markets. This is in line with the idea that costs are higher over the weekend, both due to increased uncertainty (since there are two non-trading days) and to longer periods of foregone alternative investment opportunities. The Friday effect was also documented in Bessembinder, while others have found evidence of a Wednesday rather than Friday effect explained by Wednesday contracts being the ones settled on the day after the weekend (see reference in Bollerslev and Melvin). Here there are no significant Wednesday effects.

In terms of in sample performance, adjusted R^2 for the models is anywhere from 0 to 73 percent. For the pre-crisis period with the simplest specification (which includes only the conditional variance of the exchange rate) the average is 12 percent both for the models using absolute and percentage spreads, while it increases to over 25 percent if the entire sample is used. This observation suggest that the jump in spreads that takes place in the crisis is accompanied by a jump in at least some of the explanatory variables, and this variance is (at least to some extent) picked up by the model.

Adding the lagged dependent variable to the explanatory variables increases the adjusted R^2 by around 20 percent on average to between 36 to 47 percent. Adding the whole battery of other explanatory variables adds another 7 percent on average when the entire sample is used, but reduces it slightly if only the pre-crisis samples are used. The overall picture suggests that the model with absolute spreads work marginally better than the percentage spread models, and that the bulk of the in-sample explanatory power comes from the conditional variance and lagged dependent variable. As mentioned in the previous section, there are several cases where the other variables have significant coefficients, however, the impact on adjusted R^2 seems limited.

B. Were Spreads Excessive in the Crisis?

To analyze if crisis spreads were excessive (in a statistical sense), a standard event study approach is used.[16] Excess spreads (*ES*) are computed for each currency over the crisis period by subtracting spreads predicted by one of the six models estimated in the pre-crisis period from actual spreads. The excess spreads are then aggregated over the crisis period to obtain cumulative excess spreads (*CES*).

Formally, for each country *i* the excess spread is computed as

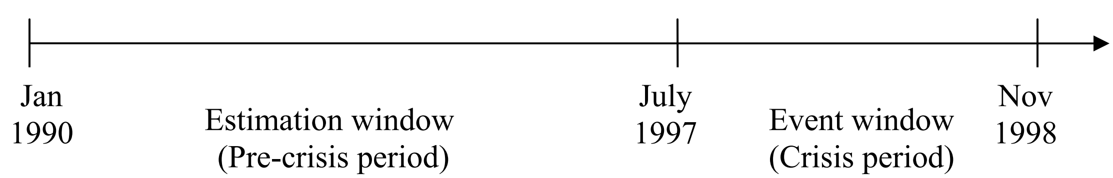
$$ES_{i,t} = S_{i,t} - \hat{\alpha}_i^{pre-crisis} X_{i,t} \quad (4)$$

where $\hat{\alpha}_i^{pre-crisis}$ is the vector of pre-crisis coefficient estimates from equation (3) and *X* is the set of independent variables. The cumulative excess spreads for each country *i* is

$$CES_i = \sum\nolimits_{crisis} ES_i \; . \quad (5)$$

Excess spreads are computed using parameter estimates for all of the six models discussed above, where models 1-3 use the absolute spread and models 4-6 the percentage spread as the dependent variable *S*.

Figure 2. Time-line of the Event Study



By using pre-crisis estimates, only changes in the explanatory variables are allowed to affect the predicted spreads. From Table 3 it is evident that the conditional variance of the exchange rates increases quite dramatically in the crisis period, and given the positive coefficient this variable has in the spread equations, this suggests that the spreads should also increase. The question is if this is enough to explain the massive increase in spreads or if there is statistical evidence that supports the view that spreads were excessive in the crisis period.

Table 6 reports cumulative abnormal spreads for all six model specifications. There are some cases of excess (or positive abnormal) spreads for the models that use absolute spreads as the

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[16] See, for example, Chapter 4 in Campbell, Lo and MacKinlay, (1997).

dependent variable, notably for several of the countries that went from a fixed to a floating regime in the crisis. However, there are very few cases of excessive spreads for the models that use percentage spreads. Instead, for most cases actual spreads were tighter during the crisis period than the spreads predicted by the models using pre-crisis estimates.

Table 6. Cumulative Excess Spreads during the Crisis

	1	2	3	4	5	6
TB CES	46.22	25.14	19.90	43.72	-34.50	-28.41
t-stat	90.74	51.29	34.01	24.00	-19.76	-13.69
adj t-stat	67.95 30	.58	20.12 18	.38	-11.67	-8.06
RP CES	49884	17886	6396	5.45	-1580.39	-1055.30
t-stat	874.88	382.73	265.57	1.96	-700.05	-1116.06
adj t-stat	80.87	33.05	11.12	0.25	-85.54	-49.98
W CES	-11087.09	-1795.61	-400.81	-1209.80	-179.71	-36.75
t-stat	-404.12	-111.62	-26.28	-389.91	-98.50	-21.14
adj t-stat	-63.02 -2	4.53	-8.51 -6	5.97	-25.58	-7.90
RM CES	0.36	0.33	0.80	-25.75	-26.78	5.26
t-stat	22.31	21.46	90.10	-42.79	-46.71	15.44
adj t-stat	7.75 9.	39	31.87	-14.71	-20.12 5.	68
PHLP CES	-28.18	1.75	-166.27	-370.09	-253.96	-846.19
t-stat	-6.73	1.23	-350.83	-23.08	-44.74	-465.95
adj t-stat	-5.89	1.20	-11.53 -2	0.14	-43.24 -1	5.67
S$ CES	-0.13	-0.05	0.13	-3.05	1.54	2.60
t-stat	-13.34	-5.22	28.38	-5.07	2.70	8.34
adj t-stat	-11.22 -4	.70	22.59 -4	.43	2.49	6.54
HK$ CES	0.00	0.00	-0.04	0.00	0.01	-0.52
t-stat	-0.03	0.05	-9.06	0.00	0.08	-9.03
adj t-stat	-0.03 0.	05	-7.66 0.	00	0.08	-7.63
Y CES	-1.10	-1.05	-2.51	-4.47	-4.44	-2.00
t-stat	-1.69	-1.63	-6.56	-8.74	-8.69	-5.46
adj t-stat	-1.69	-1.62	-6.37 -8	.71	-8.66 -5	.31

Note: Models 1-3 use absolute spreads and models 4-6 percentage spreads as dependent variable.

To assess the statistical significance of the cumulative abnormal spread a standard deviation is needed. With the null hypothesis that neither the mean, nor the variance changes in the event window, the standard errors from the pre-event period can be used to compute t-statistics. However, there are indications that the variance increase significantly during the crisis period, and an adjusted t-statistic that is based on forecast standard errors that include the parameter uncertainty associated with the models is also reported in Table 6. The forecast standard error is significantly larger than the pre-event standard error since the independent variables diverge substantially from their pre-crisis averages during the crisis (in particular the conditional variances) for many currencies.

Although significance levels are reduced substantially in many cases when the forecast standard error is used, the conclusions regarding excess spreads do not change. Both the standard and adjusted t-statistics indicate that cumulative abnormal spreads are significant in several cases, but there are many more cases of significant negative abnormal spreads than positive. The conclusion therefore is that there is little statistical support for the view that spreads were excessive during the crisis. The widening of spreads can (more than fully) be explained by changes in the level of the exchange rate and the increase in volatility of the exchange rate for most of the Asian currencies in this study.

V. Concluding Remarks

The main conclusions of the paper are that bid-ask spreads were not excessive during the Asian crisis and that the models used to explain spreads for mature market currencies seems to work even better for emerging market currencies, at least in terms of adjusted R-squares. As for the main question of spreads being excessive or not, it should be noted that this paper only addresses the issue in a statistical sense. Spreads could still be viewed as excessive from a normative or economic perspective if market intermediaries were extracting rent during turbulent times due to their position in the market. The IIF (1999) report indicates that banks did indeed make large profits. At the same time, other intermediaries exited the market, which suggests that potential or expected profits were not high enough to compensate them for the increased volatility and risk associated with currency trading during the crisis episode.

A number of results from the study have been omitted from the main presentation to keep the paper focused on the key issues. Since they may be of interest for future research in this area they will be briefly mentioned here. First, bid-ask spreads are correlated between markets on a daily basis, and this correlation increased significantly during the crisis. One reason for this correlation is that exchange rate volatility is also correlated between currencies and increased significantly during the crisis. To what extent this is driven by common macroeconomic shocks or microstructure reasons remains to be investigated. A more detailed analysis of how exchange rate volatility and bid-ask spreads in various markets are correlated may provide a new channel of contagion and could make a contribution to that literature as well.[17]

Finally, there are a number of ways the current analysis could be extended and improved. Within the modeling framework used here, there are other ways to measure exchange rate risk that may be more relevant to market makers decisions and improve how well bid-ask spreads are predicted. In particular, the conditional variance generated by GARCH models are based on historical data and does not provide a forward looking measure of perceived exchange rate risk. One way of generating forward looking measures of exchange rate risk is to use implied volatility from currency option prices. Unfortunately, the lack of derivatives instruments in emerging markets (at least historically) makes this approach difficult to implement for a large

[17] As the current literature on contagion has shown, correlation measure may be biased when the sample include subperiods with large differences in the variance measure, see Forbes and Rigobon (2001).

set of currencies. An alternative model free measure of exchange rate risk could be realized volatility. This would require using higher frequency data to compute the exchange rate risk and then use this in a lower frequency model of bid-ask spreads. Although it would be hard to do this for a model of daily bid-ask spreads for these currencies, it could probably be done for a monthly model, which may serve as a robustness check of the results from the model estimated with daily data.

APPENDIX

Table A1. Frequency Distributions of Absolute Spreads[a,b]

Currency	Pre-crisis					Crisis				
	1	**2**	**3**	**Mean**	**Max**	**1**	**2**	**3**	**Mean**	**Max**
TB	20	10	30	21.9	300	200	300	100	274	1000
	(66)	(86)	(92)		(0.1)	(33)	(56)	(72)		(2)
RP	300	100	200	329	1500	30000	20000	3000	20734	125000
	(23)	(46)	(68)		(0.1)	(20)	(39)	(49)		(0.3)
W	10	20	30	62	1500	400	500	300	522	4000
	(42)	(64)	(74)		(0.1)	(28)	(46)	(62)		(1)
RM	10	20	15	14	100	100	50	95	105	810
	(68)	(81)	(86)		(0.2)	(32)	(45)	(57)		(0.3)
PHLP	500	100	400	278	1000	500	1000	400	595	2700
	(18)	(34)	(45)		(3)	(15)	(30)	(42)		(0.3)
S$	10	20	5	11	50	20	30	10	23	70
	(74)	(81)	(87)		(0.7)	(32)	(58)	(82)		(0.3)
HK$	10	5	20	10	74	10	5	20	10	50
	(81)	(88)	(92)		(0.1)	(76)	(88)	(93)		(0.6)
Y	5	10	7	7	100	5	10	7	7	10
	(49)	(85)	(97)		(0.1)	(50)	(95)	(98)		(45)

[a]The absolute spreads have been scaled to make the smallest absolute spread observed an integer, so TB is multiplied by 1000, RP by 100, W by 100, RM by 10000, PHLP by 1000, S$ by 10000, HK$ by 10000, and Y by 100.

[b]The table contains the 3 most common spreads with cumulative frequency in parenthesis. The Max spreads are with frequency in parenthesis.

Table A2. Mean Percentage Spreads[a]

	Pre crisis	96/97	Crisis	Full sample
TB	0.087	0.131	0.683	0.193
RP	0.159	0.088	2.159	0.495
W	0.075	0.345	0.422	0.128
RM	0.052	0.040	0.283	0.087
PHLP	1.062	0.237	1.635	1.181
S$	0.071	0.069	0.140	0.081
HK$	0.013	0.012	0.014	0.013
Y	0.062	0.060	0.057	0.061

[a]Unscaled absolute spreads divided by the midpoint of the exchange rate

Table A3. Coefficient Estimates
(shaded indicates significance at 5% level)

Constant

Model	1			2			3		
Sample	pre-crisis	crisis f	ull	pre-crisis	crisis	full	pre-crisis	crisis Full		Mean
TB	19	230	47	12	124	12	-0.7	771	-109	**123**
RP	331	14637	1647	139	6394	561	-163	-126137	-16704	**-13255**
W	54	467	116	12	326	41	-43	-1275	-59	**-40**
RM	12	66	17	8.3	45	10	11	-591	-21	**-49**
PHLP	242	230	246	15	132	50	33	2909	47	**434**
S$	10	18	11	6.5	12	6.7	7.2	-42	3.6	**4**
HK$	10	10	10	8.1	7.2	7.9	8.0	22	8.1	**10**
Y	6.9	6.9	7.0	6.2	6.7	6.3	3.6	18	5.0	**7**
Mean	**86**	**1958**	**263**	**26**	**881**	**87**	**-18**	**-15541**	**-2104**	**-1596**

Model	4			5			6			
Sample	pre-crisis	crisis f	ull	pre-crisis	crisis	full	pre-crisis	crisis f	ull	Mean
TB	76	557	142	48	404	70	9.2	3812	-255	**540**
RP	16	156	29	6.4	104	21	-3.5	-546	-217	**-48**
W	6.7	34	12	1.9	23	5.1	-3.9	-133	-3.6	**-6.4**
RM	464	1873	609	327	1356	430.8	402	-9323	-418	**-475**
PHLP	913	561	947	46	194	195	148	13437	814	**1917**
S$	633	1117	688	455	789	455	354	-1854	220	**318**
HK$	123	126	124	105	93	103	104	285	105	**130**
Y	5.4	5.2	5.8	5.3	4.8	5.6	6.2	24	7.3	**7.7**
Mean	**280**	**554**	**319**	**124**	**371**	**161**	**127**	**713**	**32**	**298**

Table A3. Coefficient Estimates (continued)
(shaded indicates significance at 5% level)

Conditional variance

Model	1			2			3			
Sample	pre-crisis	crisis	full	pre-crisis	crisis	full	pre-crisis	crisis	full	Mean
TB	0.28	0.10	0.23	0.19	0.04	0.04	0.18	0.03	0.04	**0.12**
RP	2.35	2.85	4.85	1.36	0.75	1.15	2.38	1.22	1.03	**1.99**
W	7.10	0.10	0.19	1.49	0.08	0.07	0.51	0.17	0.15	**1.10**
RM	0.30	0.15	0.23	0.20	0.11	0.14	0.15	0.09	0.12	**0.17**
PHLP	1.70	1.44	1.41	0.07	0.64	0.24	3.26	0.71	0.85	**1.15**
S$	0.25	0.08	0.14	0.14	0.05	0.08	0.05	0.04	0.06	**0.10**
HK$	4.53	3.65	4.34	3.71	2.51	3.44	5.59	2.26	4.69	**3.86**
Y	0.01	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00	**0.01**
Mean	**2.06**	**1.05**	**1.42**	**0.90**	**0.52**	**0.65**	**1.52**	**0.57**	**0.87**	**1.06**

Model	4			5			6			
Sample	pre-crisis	crisis	full	pre-crisis	crisis	full	pre-crisis	crisis	full	Mean
TB	1.09	0.28	0.59	0.76	0.19	0.20	0.75	0.15	0.21	**0.47**
RP	0.08	0.03	0.05	0.03	0.01	0.02	0.08	0.01	0.02	**0.04**
W	0.75	0.01	0.01	0.11	0.00	0.00	0.01	0.01	0.01	**0.10**
RM	11.20	3.59	5.62	7.41	2.69	3.46	5.47	2.12	3.03	**4.96**
PHLP	6.99	4.22	3.36	0.76	1.26	-1.14	12.90	1.16	1.62	**3.46**
S$	12.35	4.10	7.99	6.75	2.44	4.84	4.03	2.18	3.23	**5.32**
HK$	58.31	47.22	55.96	47.86	32.42	44.39	71.78	29.09	60.29	**49.70**
Y	0.02	0.00	0.00	0.02	0.00	0.00	0.01	0.01	0.01	**0.01**
Mean	**11.35**	**7.43**	**9.20**	**7.96**	**4.88**	**6.47**	**11.88**	**4.34**	**8.55**	**8.01**

Interest rate differential

Model	3			6			
Sample	pre-crisis	crisis	full	pre-crisis	crisis	full	Mean
TB	15.18	-9.63	4.00	51.53	27.58	21.44	**18.35**
RP	7.18	102.01	220.66	0.25	-0.39	1.06	**55.13**
W	-11.16	59.92	-4.04	-1.03	7.88	1.51	**8.85**
RM	-0.01	-1.69	1.98	0.27	-33.26	39.78	**1.18**
PHLP	4.50	-105.45	-29.86	16.99	-384.00	-78.35	**-96.03**
S$	-0.73	1.52	-0.31	-47.95	97.01	-21.01	**4.76**
HK$	1.00	0.53	0.35	12.89	6.85	4.55	**4.36**
Y	0.24	0.37	0.07	-0.35	0.63	-0.49	**0.08**
Mean	**2.02**	**5.95**	**24.11**	**4.08**	**-34.71**	**-3.94**	**-0.42**

Table A3. Coefficient Estimates (continued)
(shaded indicates significance at 5% level)

Lagged spread

Model	3			6			
Sample	pre-crisis	crisis f	ull	pre-crisis	crisis f	ull	Mean
TB	0.40	0.37	0.63	1.46	0.40	1.21	**0.74**
RP	0.52	0.47	0.53	0.02	0.003	0.003	**0.26**
W	0.77	0.46	0.60	0.09	0.03	0.05	**0.33**
RM	0.21	0.08	0.27	7.72	2.20	6.82	**2.88**
PHLP	0.51	0.33	0.52	1.98	1.20	1.94	**1.08**
S$	0.29	0.21	0.30	19.32	11.69	17.04	**8.14**
HK$	0.12	0.20	0.16	1.53	2.53	2.07	**1.10**
Y	0.06	-0.02	0.05	0.05	0.00	0.04	**0.03**
Mean	**0.36**	**0.26**	**0.38**	**4.02**	**2.26**	**3.65**	**1.82**

Expected volume

Model	3			6			
Sample	pre-crisis	crisis f	ull	pre-crisis	crisis f	ull	Mean
TB	0.04	0.13	0.09	0.13	0.33	0.14	**0.14**
RP	0.13	-12.16	-13.61	0.01	-0.05	-0.03	**-4.29**
W	0.27	-2.71	-0.50	0.02	-0.23	-0.11	**-0.54**
RM	-0.01	-0.16	-0.09	-0.36	-4.30	-2.08	**-1.17**
PHLP	0.01	-0.22	-0.03	0.02	-0.92	-0.14	**-0.22**
S$	-0.01	0.09	0.04	-0.81	5.14	1.99	**1.08**
HK$	0.00	0.00	0.00	-0.02	0.03	0.00	**0.00**
Y	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Mean	**0.05**	**-1.88**	**-1.76**	**-0.13**	**0.00**	**-0.03**	**-0.62**

Unexpected volume

Model	3			6			
Sample	pre-crisis	crisis f	ull	pre-crisis	crisis f	ull	Mean
TB	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
RP	0.02	0.17	0.18	0.00	0.00	0.00	**0.06**
W	-0.03	0.31	0.18	0.00	0.02	0.00	**0.08**
RM	0.00	0.01	0.01	0.01	0.33	0.20	**0.09**
PHLP	0.00	-0.01	-0.0004	0.00	-0.03	-0.002	**-0.01**
S$	0.00	0.01	0.01	0.07	0.35	0.36	**0.13**
HK$	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Y	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
Mean	**0.00**	**0.06**	**0.05**	**0.01**	**0.08**	**0.07**	**0.04**

Table A3. Coefficient Estimates (concluded)
(shaded indicates significance at 5% level)

Monday dummy

Model	3			6			
Sample	pre-crises	crises	full	pre-crises	crises	full	Mean
TB	-3.92	-7.62	-5.91	-14.89	3.08	-7.66	**-6.15**
RP	-18.54	-4272.08	-1796.69	-0.68	-31.79	-11.89	**-1021.95**
W	7.72	-55.05	-3.13	0.90	-2.61	0.14	**-8.67**
RM	-0.38	-5.33	0.05	-14.08	-161.01	-3.81	**-30.76**
PHLP	6.33	-66.95	-22.07	24.56	-227.73	-74.29	**-60.02**
S$	-0.78	-1.44	-0.96	-53.01	-80.86	-59.21	**-32.71**
HK$	0.04	-0.44	-0.05	0.49	-5.73	-0.69	**-1.07**
Y	-0.43	0.40	-0.23	-0.35	0.24	-0.22	**-0.10**
Mean	**-1.24**	**-551.06**	**-228.62**	**-7.13**	**-63.30**	**-19.70**	**-145.18**

Friday dummy

Model	3			6			
Sample	pre-crises	crises	full	pre-crises	crises	full	Mean
TB	4.82	10.75	4.88	19.51	29.53	18.24	**14.62**
RP	4.97	2451.26	759.07	0.34	24.970	9.535	**541.69**
W	7.08	-67.03	-3.91	0.73	-5.52	-0.41	**-11.51**
RM	0.97	-5.28	-0.37	38.27	-126.67	5.46	**-14.60**
PHLP	-50.38	63.64	7.55	-199.44	192.34	26.68	**6.73**
S$	0.70	3.55	1.25	47.23	211.66	80.58	**57.50**
HK$	0.63	0.71	0.67	8.20	9.24	8.68	**4.69**
Y	1.73	0.72	1.52	1.68	0.49	1.43	**1.26**
Mean	**-3.68**	**307.29**	**96.33**	**-10.43**	**42.01**	**18.77**	**75.05**

Table A4. Adjusted R-squares
(in percent)

Model	1			2			3			
Sample	pre-crisis	crisis	full	pre-crisis	crisis	full	pre-crisis	crisis	full	Mean
TB	45	15	37	49	32	70	49	22	68	**43**
RP	3	18	45	35	48	71	64	55	70	**45**
W	16	10	16	69	17	51	73	28	61	**38**
RM	8	21	47	17	28	56	17	40	67	**33**
PHLP	6	35	34	89	50	75	28	54	78	**50**
S$	5	11	29	16	21	39	12	33	55	**25**
HK$	9	6	8	11	12	11	22	20	22	**13**
Y	0	1	0	1	0	1	13	3	10	**3**
Mean	**12**	**15**	**27**	**36**	**26**	**47**	**35**	**32**	**54**	**31**

Model	4			5			6			
Sample	pre-crisis	crisis	full	pre-crisis	crisis	full	pre-crisis	crisis	full	Mean
TB	50	22	42	54	28	65	54	26	63	**45**
RP	1	24	51	35	41	68	62	44	69	**44**
W	14	6	8	68	15	47	72	27	56	**35**
RM	8	20	45	16	27	54	15	31	65	**31**
PHLP	7	29	17	88	49	72	29	58	73	**47**
S$	3	10	27	13	19	37	13	29	51	**23**
HK$	9	6	8	11	12	11	22	20	22	**13**
Y	2	1	0	2	2	0	15	10	14	**5**
Mean	**12**	**15**	**25**	**36**	**24**	**44**	**35**	**31**	**51**	**30**

Table A5. Correlations Between Absolute Spreads
(Pre-crisis correlations in the lower and crisis correlations in the upper triangle.)

	TB	**RP**	**W**	**RM**	**PHLP**	**S$**	**HK$**	**Y**
TB		0.12	0.07	0.18	0.33	0.31	0.23	0.08
RP	0.07		0.09	0.24	-0.14	0.47	-0.06	-0.05
W	0.11	-0.08		0.17	0.10	0.07	0.03	-0.02
RM	0.09	0.10	-0.08		-0.07	0.32	0.09	-0.05
PHLP	0.03	0.27	-0.28	0.24		-0.05	0.14	0.04
S$	0.04	0.12	0.00	0.41	0.13		0.06	0.04
HK$	0.05	0.11	-0.01	0.19	0.09	0.39		-0.00
Y	0.10	0.05	0.08	0.14	-0.00	0.20	0.15	

Table A6. Correlations Between Conditional Variances
(Pre-crisis correlations in the lower triangle and crisis correlations in the upper triangle.)

	TB	**RP**	**W**	**RM**	**PHLP**	**S$**	**HK$**	**Y**
TB		0.17	0.14	0.23	0.14	0.13	0.11	-0.16
RP	0.07		0.32	0.65	0.45	0.42	0.41	-0.07
W	-0.02	0.26		0.12	0.43	0.06	0.07	-0.14
RM	0.10	0.05	-0.05		0.51	0.48	0.33	-0.21
PHLP	-0.05	-0.04	-0.15	-0.06		0.32	0.25	-0.29
S$	-0.02	0.28	0.16	0.17	0.07		0.33	0.21
HK$	-0.00	0.18	-0.07	0.03	-0.01	0.26		0.03
Y	0.19	0.06	0.13	0.02	-0.15	0.41	0.14	

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