Trading volumes, volatility and spreads in FX markets: evidence from emerging market countries

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Abstract

This paper provides empirical evidence on the relationship between trading volumes, volatility and bid-ask spreads in foreign exchange markets. It uses a new data set that includes daily data on trading volumes for the dollar exchange rates of seven currencies from emerging market countries. The sample period is 1 January 1998 to 30 June 1999. The results are broadly consistent with the findings of the literature that used futures volumes as proxies for total foreign exchange trading. I find that in most cases unexpected trading volumes and volatility are positively correlated, suggesting that both are driven by the arrival of public information, as predicted by the mixture of distributions hypothesis. I also find evidence of a positive correlation between volatility and spreads, as suggested by inventory cost models. However, contrary to the prediction of these models, I do not find evidence of a significant impact of unexpected trading volumes on spreads.

1. Introduction

This paper looks at the relationship between trading volumes, volatility and bid-ask spreads in foreign exchange markets. A number of studies on the microstructure of foreign exchange markets have looked at this issue from both a theoretical and an empirical point of view. From a policy perspective, the issue is important for its implications for the analysis of market liquidity and its relationship with risk. Broadly speaking, a market can be considered to be liquid when large transactions can be executed with a small impact on prices (BIS (1999a)). In practice, however, no data are available that allow to measure this definition of foreign exchange market liquidity directly. Instead, trading volumes or bid-ask spreads are often used as indirect measures. Volatility is often considered as a measure of risk.

The empirical microstructure literature has typically found a positive correlation between volumes and volatility. A theoretical explanation of this finding is that volume and volatility are both driven by a common, unobservable factor, which is determined by the arrival of new information. This theory, also known as the mixture of distributions hypothesis, predicts that volatility moves together with unexpected trading volumes. A further common finding of the literature is that volume and spreads are positively correlated. The explanation provided by microstructure theory is that bid-ask spreads are determined inter alia by inventory costs, which widen when exchange rate volatility increases. Through the mixture of distributions hypothesis, this also establishes a positive link between unexpected volumes and spreads.

An important drawback of empirical studies in this area is that good data on foreign exchange trading volumes are generally not available at high frequencies. The most comprehensive source of information on trading in foreign exchange markets, the *Triennial Survey of Foreign Exchange and Derivatives Market Activity* published by the BIS, for example, does not provide much information on the time series behaviour of trading volumes. Researchers have therefore looked at alternative data sources to find proxies for foreign exchange market turnover.

This paper uses a new data set that for the first time matches daily data on trading volumes, volatility and spreads. The data set covers the dollar exchange rates of seven currencies from emerging market countries, the Colombian peso, the Mexican peso, the Brazilian real, the Indian rupee, the Indonesian rupiah, the Israeli shekel and the South African rand. The data cover the period from January 1998 to June 1999. Since there is not much offshore trading in these currencies, local transaction volumes are fairly representative of total trading. In order to allow a comparison with foreign exchange markets in industrial countries and with the results from previous studies, the paper also looks at trading volumes from the Tokyo interdealer yen/dollar market. Finally, for the Mexican peso, data from a fairly active currency futures market on the Chicago Mercantile Exchange were also obtained. These data allow a direct comparison of volumes on foreign exchange and futures markets.

A main finding using this data set is that in most cases unexpected trading volume and volatility are positively correlated, suggesting that they both react to the arrival of new information, as the mixture of distributions hypothesis predicts. This result is in line with the findings of the literature that relies on futures data. The markets for the Mexican peso and the real, however, provide important exceptions. In these two cases, the relationship between unexpected volumes and volatility is not statistically significant. I also find evidence of a positive correlation between volatility and spreads, as suggested by inventory cost models. However, the results do not show a significant impact of trading volumes on spreads.

The remainder of the paper is organised as follows. Section 2 reviews the main contributions to the literature on the relationship between trading volumes, volatility and spreads. Section 3 describes the data set that is used. In Section 4, I present some descriptive evidence on the relationship between volumes, volatility and spreads. I then use regression analysis to test whether the mixture of distribution hypothesis holds in foreign exchange markets. Section 5 concludes.

2. Literature review

There is an extensive literature on the relationship between trading volumes and volatility in financial markets. Karpoff (1987) provides a good overview of the early literature. Most of the research has focused on stock markets and futures markets, for which data on volumes are more easily available. An important finding is that trading volume and price variability are positively correlated at different frequencies. The coefficient is highest for contemporaneous correlations. However, it does not always appear to be very sizeable. Evidence was found by Harris (1986) and Richardson et al. (1987) for stock markets and by Cornell (1981) for commodity futures.

The empirical work on foreign exchange markets has suffered from the problem that good data on trading volumes are not easily available for foreign exchange markets, since unlike equity markets, they are for a large part decentralised. Different data sources were used to describe the time series behaviour of trading volumes.[1] Many studies used data on futures contracts, which can be easily obtained, to proxy for interbank trading volumes. Studies that have found a positive correlation between volumes and volatility in these markets include Grammatikos and Saunders (1986), Batten and Bhar (1993) and Jorion (1996). An obvious drawback of these data sets is that trading in futures is very small compared to OTC volumes (Dumas (1996)). In the first quarter of 1998, for example, total turnover of currency futures traded on organised exchanges amounted to roughly $70 billion (BIS (1998)), compared to total OTC turnover in spot, forward and swap markets of about $1500 billion (BIS (1999b). While these two markets may still be closely linked through arbitrage (Lyons (2000)), little evidence is available on this link.

A widely used source of information on foreign exchange trading, the *Triennial Survey of Foreign Exchange and Derivatives Market Activity* published by the BIS, provides extensive cross-sectional information but very little information on the time series behaviour of turnover. Hartmann (1998b) makes efficient use of these data by combining a large cross-section of exchange rates taken from the BIS Triennial Survey with two time series observation into a panel but still faces the problem of having limited time series information.

A number of papers analysed data on indicative quotes provided by Reuters through its FXFX page.[2] However, these quotes do not represent actual trades and it is not possible to infer from a quote for which volume it is given. Spreads that are quoted on the Reuters screen are generally far from actual, traded spreads.[3] Moreover, it is common for banks that act as data providers to program an automated data input, e.g. by having a particular quote entered at regular time intervals. This is especially true for smaller banks that may have an interest in quoting prices in order to advertise their presence in a particular market segment. Finally, when an important event occurs, traders are likely to act and trade rather than entering data for Reuters. Hence, Reuters tick frequency may be low at times

1 A good overview of the characteristics of data sets used in the literature can be found in Lyons (2000).

2 See, eg Goodhart and Figliuoli (1991), Bollerslev and Domowitz (1993). And Melvin and Yi (2000).

3 See also Hartmann (1998a) , p.142.

of high trading activity and high when markets are calm. The relationship between quote frequency and actual trading activity is therefore likely to be quite noisy.

An alternative source of information is the Bank of Japan's data set on brokered transactions in the Tokyo yen/dollar market, which has been used by Wei (1994) and Hartmann (1999). Again, a problem with these data is that they represent only a fraction (about one-sixth) of total turnover in the Tokyo yen/dollar market and not more than 5% of the global yen/dollar market.

A fruitful approach has been to look at high-frequency data on actual transactions in the OTC market. One such data set, used by Lyons (1995), covers all transactions that a foreign exchange dealer in New York entered with other dealers in one week in 1992. Goodhart, Ito and Payne (1996) analyse data on electronically brokered interdealer transactions that occurred on one day in 1993. While these data provide a wealth of information, including information on the direction of order flows, they necessarily cover only a limited segment of foreign exchange markets and span a relatively short time period.

Different theoretical explanations have been offered for the co-movement of trading volumes and volatility. Early work was based on models of "sequential information arrival" (Copeland (1976,1977)), according to which information reaches one market participant at a time. As that agent reacts to the arrival of news, his demand curve will shift, thereby leading to a positive correlation between volume and volatility. An alternative explanation of the volume-volatility correlation is based on the "mixture of distribution hypothesis" first proposed by Clark (1973). According to this hypothesis, volume and volatility are both driven by a common, unobservable factor. This factor reflects the arrival of new public information, and determines a positive correlation between unexpected turnover and unexpected volatility. Tauchen and Pitts (1983) show that volume and volatility can co-move for two reasons. First, as the number of traders grows, market prices become less volatile. Second, given the number of traders, an increase in volume reflects a higher disagreement among traders and hence leads to higher volatility. This link is stronger when new information arrives at a higher rate.

A number of studies looked at the relationship between volumes and volatility by testing the common observation that in both bond and equity markets, an upward movement of the market is generally associated with higher transaction volumes. The empirical evidence for this relationship is weak. While some studies (e.g. Epps (1975, 1977), Rogalski (1978) and Richardson et al. (1987)) have found weakly supportive evidence, other studies (e.g. James and Edminster (1983) and Wood et al. (1985)) have failed to detect any significant correlation. Moreover, no favourable evidence has been found for futures markets.

Models that explain bid-ask spreads in terms of inventory costs establish a link between bid-ask spreads, volatility and trading volumes. One determinant of inventory costs is the cost of maintaining open positions, which is positively related to price risk.[4] According to this view, exchange rate volatility increases price risk and thereby pushes up spreads. Supportive evidence is provided by Bessembinder (1994), Bollerslev and Melvin (1994) and Hartmann (1999), who found a positive correlation between spreads and expected volatility measured by GARCH forecasts.

A second determinant of inventory costs is trading activity. Trading volumes can have a different impact on spreads depending on whether they are expected or unexpected. Expected trading volumes should be negatively correlated with spreads to the extent that they reflect economies of scale and are associated with higher competition among market makers (Cornell (1978)). By contrast, unexpected trading volumes should have a positive impact on spreads to the extent that they are associated with higher volatility through the mixture of distribution hypothesis.

4 The microstructure literature analyses two other types of costs, order processing costs (i.e. costs of providing liquidity services) and asymmetric-information costs (Bessembinder (1994), Jorion (1996) Hartmann (1999), Lyons (2000)). While order processing costs are arguably small in foreign exchange market (Jorion (1996)), there is no consensus on the importance of asymmetric-information costs.

3. The data

Exchange rates

This paper looks at the dollar exchange rates of seven currencies from emerging market countries: the Indonesian rupiah, the Indian rupee, the Mexican peso, the Brazilian real, the Colombian peso, the South African rand and the Israeli shekel.[5] The sample period is January 1998 to June 1999.[6] According to the IMF classification, during this period these exchange rates either floated independently or were managed in some form (Table 1). Figure 1 and Table 2 provide information on their behaviour. As a benchmark for comparison, information on the yen/dollar rate is also shown. Overall, all seven emerging market currencies depreciated against the dollar. The depreciation was particularly sharp following the Russian crisis in August 1998, except in the case of the real.

The real depreciated at a constant rate against the dollar in 1998. Following intense speculative pressures, Brazilian authorities had to float it freely on 15 January 1999 and it plunged from 1.1 to almost 2.2 real/dollar. The real recovered somewhat in the following months, and in June 1998 traded around a level of 1.75 to the dollar. The Mexican peso depreciated through most of 1998 and early 1999. However, it moved within a much smaller range than the real. The Mexican peso's weakness was exacerbated following the Russian crisis in August 1998, when it depreciated by around 20% against the dollar. It also fell, albeit not as much, in January 1999, during the period of speculative attacks on the real. The Colombian peso's downward trend and fluctuation range against the US dollar were similar to those of the Mexican peso. In August 1998, pressure on the peso stepped up, inducing the authorities to widen the intervention band by 9%, effectively devaluing the currency. The peso came under renewed pressure in March 1999 and June 1999, when it devalued by about 20%.

The Indian rupee's behaviour was characterised by periods of stability followed by sharp downward movements. The Indonesian rupiah fell sharply in January and in July 1998. Its volatility declined in 1999 but remained still very high.

The South African rand depreciated markedly against the dollar around the time of the Russian crisis in the summer of 1998. In the following months it recouped part of its losses but in 1999 trended down again. In 1998, the shekel followed a slightly depreciating trend against the dollar. It fell by 20% after the Russian crisis but stabilised in the following weeks.

Figure 3 and Table 3 report information on the percentage exchange rate changes for the seven currencies. For the real, statistics are presented also separately for the period January-June 1999, during which it floated. Between January 1998 and June 1999, the average daily percentage change of most of the currencies was significantly positive, with the exceptions of the Colombian peso and the rupee. Their standard deviation ranged between 0.29 for the rupee and 4.24 for the rupiah. Over the same period, the standard deviation of the yen/dollar rate was close to 1. Most exchange rate changes exhibited positive skewness, consistently with their downward trend, and leptokurtosis. Table 4 suggests that the exchange rate changes exhibited very little persistence.

Volatility

Figure 3 shows the historical volatility of the seven exchange rates computed over moving windows of one month. Summary statistics are reported in Table 5. In terms of their volatility, the seven exchange rates can be divided into two groups. The real and the rupiah experienced sharp volatility spikes and were characterised by very high average volatility. By contrast, the historical volatilities of the rupee, the shekel and the Colombian peso remained quite low, averaging less than 8%. The rand's volatility was relatively low on average, but it spiked at about 50%.

Table 5 shows that the volatility of the yen/dollar exchange rate during the same period averaged 15%. This is much less than the volatility of the exchange rate of the real or the rupiah vis-à-vis the dollar, but more than the volatility of the other five exchange rates in this data set.

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[5] See, eg Goodhart and Figliuoli (1991), Bollerslev and Domowitz (1993). And Melvin and Yi (2000).

[6] The choice of the sample period is dictated by the availability of data on trading volumes.

A finding that is common for exchange rates and other asset prices is the existence of volatility clustering, i.e. the fact that periods of persistent turbulence are followed by periods of relative calm. In the finance literature, this phenomenon has typically been described by some ARCH-type models. Tests for ARCH-type effects presented in Table 6 suggest that the exchange rates under investigation - possibly with the exception of the Colombian peso - exhibit some ARCH-type behaviour. This behaviour seems to be fairly well captured by a GARCH (1,1) model.

Finally, Table 7 present evidence that for half of the exchange rates, volatility follows a time trend. The trend is positive for the Colombian peso and the real and negative for the rupee and rupiah. There is no evidence of weekend effects.

Trading volumes

A large literature has documented the behaviour of trading volumes in stock markets and bond markets. By contrast, there is relatively little work on foreign exchange markets because of the difficulty of obtaining data with a sufficiently high frequency in this decentralised market. In this paper I use daily data on local turnover on seven exchange rates from emerging market countries. The sample period is January 1998 to June 1999, except for the rupiah, for which data are available only from 1 January to 30 June 1999. Since there is not much offshore trading in these currencies, local transaction volumes are fairly representative of total trading.[7] As a benchmark, I also included trading volumes from the Tokyo interbank market, which were used in previous studies. The time series of the trading volumes are shown in Figure 1 and summary statistics are reported in Table 8.

A comparison with data from the 1998 Triennial Survey suggests that taken together, trading in the seven currency pairs accounts for roughly 1-2% of total foreign exchange market turnover. The individual markets are characterised by very different levels of activity. The most active markets were those for the Mexican peso, the real and the rand. To get an idea of the size of these markets, trading of dollars against one of these currencies averaged about one-third of local trading of Canadian or Australian dollars against the US dollar in April 1998. Taking the yen/dollar market as a benchmark, the size of these markets is slightly smaller than the interbank market in Tokyo. The market for the rupee also appeared to be quite active ($3.5 billion a day), much more than the market for the Indonesian rupiah ($1 billion per day), which in 1995 and 1996 was the most active foreign exchange market in emerging market countries with an average daily turnover of more than $8 billion (BIS (1997)). Transaction volumes for the Colombian peso and the shekel instead are relatively small.

Figure 1 reveals some interesting facts about the behaviour of trading volumes. First, it shows also that the foreign exchange turnover involving the real, the Colombian and the Mexican peso and the rand fell substantially around the end of August 1998, at time when the Russian crisis sparked a global reduction of liquidity in financial markets. The decline in trading volumes was particularly sharp in Mexico and Brazil.

Second, while trading volumes behaved differently around periods of speculative pressures, they always fell substantially once the pressures abated.[8] This fact can be illustrated with the examples of the real and the Colombian peso. At the time of the speculative attack on the real in January 1999, trading volumes for the real rose for a short time and became more volatile. After Brazilian authorities decided to float the real on 12 January 1999, trading of reais against dollars remained very volatile for several weeks and before shrinking substantially around mid-February. In the following months, turnover built up again steadily but remained below levels observed before the crisis.

The Colombian peso was subject to two rounds of pressure in 1999. When pressure mounted first in March, there appears not to have been a significant increase in foreign exchange turnover. Following this period, daily turnover dried up from about $200 mn to less than $50 mn. At the time of the second attack on the peso in June 1999, turnover increased sharply to $150 mn or more. Since our sample period ends on 30 June 1999, it is not possible to verify how trading volumes behaved after the second attack.

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[7] Until 1997 there was a quite active rupiah/dollar market in Singapore. However, most of this activity disappeared following the Asian crisis.

[8] This is true even when volumes are measured at constant exchange rates.

Regressions of trading volumes on a constant, a linear time trend and a dummy variable capturing weekend effects show a negative trend for trading in the Colombian and Mexican peso, the real (until January 1999) and the rand. By contrast, there is evidence that turnover of the rupiah followed a positive time trend. The volume of yen/dollar transactions brokered in Tokyo instead did not exhibit any time trend. Graph 2, which plots turnover in selected emerging markets over a longer horizon (and at a lower frequency), puts these findings in perspective. It suggests that trading in emerging market currencies rose in the mid-1990s but in most cases fell after the Asian crisis and again at the time of the global reduction of liquidity in financial markets in 1998. Finally, Table 7 shows also that weekend effects appear to be present in about half of the cases.

For the Colombian peso, data on the transaction frequency is also available. It is sometimes argued that the combination of these data and trading volumes provides a good indicator on market liquidity. Table 8 suggest that for the Colombian peso/dollar exchange rate the behaviour and the statistical properties of turnover and transaction frequency are very similar.

Table 10 presents some summary statistics on the changes of daily trading volumes. On average, trading volumes for the Colombian peso, the rand, the real and the rupiah appear to be most stable. The statistic for the rupiah is particularly noteworthy and indicative of the low variability of turnover associated with the low activity after the Asian crisis. For the Colombian peso, the statistics for turnover and transaction frequency appear to be very similar. The Mexican peso and the shekel exhibit the highest average variability of trading volumes.

Futures contracts for three exchange rates, the Mexican peso/dollar, the real/dollar and the rand/dollar rate are traded on the Chicago Mercantile Exchange.[9] Table 9 provides summary statistics for these series. Trading is most active for the Mexican peso/dollar contracts, but in any case much less - no more than 3% - than OTC turnover. Figure 3 shows that on many days there is actually no trading on the exchanges at all involving the rand or the real. Exchange traded and OTC volumes appear not to have co-moved closely in 1998 and 1999. The correlation coefficient of daily percentage changes is less than 1% for the Mexican peso, 4% for the rand and 18% for the real.

Spreads

Table 12 reports summary statistics on bid-ask spreads, expressed as a fraction of the exchange rate. As a benchmark for comparison, it also provides information on the spreads on brokered yen/dollar transactions in Tokyo. A caveat about these data is that they refer to indicative quotes rather than to actual transactions. Spreads on actual trades may be much smaller (and possibly less volatile), especially when one looks at electronically brokered transactions. [10] Subject to these caveats, Table 12 shows that spreads on exchange rates from emerging market countries are much higher and much more volatile than spreads on the yen/dollar exchange rate. Their average in 1998 and 1999 ranged from 0.12% of the exchange rate for the Mexican peso to more than 2% for the rupiah, compared to spreads around 0.05% for the yen/dollar market. Table 7 provides some additional information on the variations of the bid-ask spreads.

4. Volumes, volatility and spreads

Trading volumes and volatility

A well-established fact for stock markets is that trading volumes are positively correlated with price variability.[11] A similar result has also been found for foreign currency futures (Grammatikos and Saunders (1986)). The middle panels in Graph 2 suggest that when turmoil hits foreign exchange markets, both volatility and trading volumes increase. Once the currency has depreciated markedly, trading volumes tend to fall substantially.

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9 There is also active trading in real/dollar futures contracts on the BM&F in São Paolo and on the rand in London.

10 See Lyons (1995) and Hartmann (1999) and Cheung and Chinn (1999). Most of yen/dollar spot transactions between banks are nowadays conducted through electronic brokers and have spreads about two to three hundredths of a US cent.

11 See Karpoff (1987, pp.112-3) for an overview of this literature.

In terms of the contemporaneous correlation between daily foreign exchange turnover and exchange rate volatility, Table 14 shows positive coefficients for five out of seven emerging market exchange rates (the dollar exchange rates of the Colombian peso, rand, rupee, rupiah and shekel). The correlation is also positive for the yen/dollar rate traded in the Tokyo interbank market. This holds irrespectively of whether exchange rate volatility is measured by absolute values of percentage changes, squared returns or the standard deviation of daily returns computed over rolling windows of one-month. By contrast, I find a negative correlation for the real and the Mexican peso.

Regressions of volatility on a constant, a time trend, a day-of-the-week dummy and trading volumes gives positive and statistically significant coefficients in all cases except the real and the Mexican peso (Table 16). For the Colombian peso, a regression of volatility on the number of deals per day also gives a positive and statistically significant coefficient. With the exception of the real and the Mexican peso, these results are consistent with the finding of a positive correlation of volatility and volume found for currency futures (Grammatikos and Saunders (1986), Jorion (1996)). Table 15 shows that for the Mexican peso, exchange traded data give a positive correlation between volatility and volumes. This result suggests that exchange traded data may not always be an appropriate proxy for total interbank trading.

Another interesting issue is whether trading volumes are “directional” in the sense that they increase (decrease) when asset prices increase (decrease). Testing this hypothesis involves testing for a positive correlation of volumes and price changes. There is some, albeit weak, evidence in favour of this hypothesis for stock and bond markets (Karpoff (1987)). By contrast, there is no supporting evidence for futures markets. Table 14 does not provide clear evidence of a positive relationship between volumes and price changes in foreign exchange markets. For some exchange rates - the Colombian and the Mexican peso, rand, rupee and shekel - changes are positively correlated with trading volumes but the correlation coefficients are small. The correlation coefficient is negative for the real and rupiah. The same is true for yen/dollar rate traded in Tokyo.

A related question is whether trading volume and exchange rate changes are related in an asymmetric fashion, i.e. whether volumes are higher when a currency appreciates or when it depreciates against the dollar. Karpoff (1987) argued that most empirical findings for stock markets support what he calls an “asymmetric volume-price change hypothesis”, i.e. a fundamentally different relationship between volume and price changes for positive and negative price changes. The evidence presented in Table 14 appears only weakly consistent with this hypothesis. For the Mexican peso, rupee, shekel and the yen, the relationship between volumes and exchange rate changes is almost identical in the two cases. For the other currencies, volumes change more in the case of a depreciation than in the case of an appreciation.

The positive correlation between volumes and volatility found for most of the exchange rates is unlikely to be a reflection of changes in the number of traders active in these markets. These changes appear rather to have occurred in the mid-1990s, when banks increasingly moved into emerging markets, and after the Asian crisis, when the sharp fall in turnover was accompanied by a significant decline in the number of traders. A more plausible explanation for the positive correlation between turnover and volatility is that both variables are driven by a common, unobservable factor. According to the mixture of distribution hypothesis, this factor reflects the arrival of new information, and determines a positive correlation between unexpected turnover and unexpected volatility. Moreover, as Tauchen and Pitts (1983) show, volume and volatility can co-move because, given the number of traders, an increase in volume may reflect a higher disagreement among traders, which also leads to higher volatility. The co-movement is closer when new information arrives at a higher rate.

To test this hypothesis, I split volatility and trading volumes into expected and unexpected components. I use estimates from a GARCH(1,1) model to describe expected volatility. This model appears to fit the time series well.[12] Ideally, volatility implied in option prices could be used, since there is evidence that it outperforms GARCH models in providing forecasts of future volatility.[13] However, option contracts for currencies of emerging market countries are not very liquid, particularly after the Asian crisis. The GARCH(1,1) model can be written as:

[12] Following a common practice of the literature, the GARCH-model is fitted on the entire time series, therefore yielding in-sample forecasts.

[13] Jorion (1996); Galati and Tsatsaronis (1996).

$$(1) \quad R_t = \mu + r_t, \quad r \sim N(0,h_t), \quad h_t = \alpha_0 + \alpha_1 r_{t-1}^2 + \beta h_{t-1}$$

where R_t is the return, μ its mean and h_t its conditional variance at time t.

In order to measure expected trading volumes, I used the Box-Jenkins analysis to select a parsimonious time series representation for the volume series, which are taken in logs. Time series models were fitted on the levels of trading volumes since Augmented Dickey-Fuller test suggest that they are stationary. AR models, in most cases of first order, seemed appropriate to represent the turnover series. These models allow to split trading volumes into an expected and an unexpected component.

The regression equation that is estimated takes the following form:

$$(2) \quad R_{t+1}^2 = \alpha + \beta_1 h_{t+1} + \beta_2 E_t(v) + \beta_3 [v_{t+1} - E(v)] + \beta_4 t + \beta_5 w_t + \varepsilon_{t+1}$$

where total volatility R^2_{t+1} is defined as squared returns, expected volatility h_{t+1} is the one-step-ahead conditional return variance from a GARCH(1,1) specification, and log-volumes are decomposed into an expected component $E_t(v)$ and an unexpected component $[v_{t+1}\text{-}E_t(v)]$ by using a fitted AR series and its residuals. A linear time trend and a dummy capturing weekend effects are also included.

Table 17 reports the regression results. The coefficient on unexpected turnover is positive and statistically significant at 1% or 5% in all the regressions for exchange rates from emerging market countries, except those for the Mexican peso and the real. For these two currencies, the coefficients are negative but not statistically significant. A positive, significant coefficient is also found for the yen/dollar rate traded in Tokyo. Except for the Mexican peso and the real, the results support the idea that information flow drives volatility and volumes, as implied by the mixture of distributions hypothesis. This result is consistent with the conclusion of the literature that used data on currency futures (Jorion (1996)). These results are independent of market size: they hold for both for the smallest market (Colombian peso/dollar) as for the biggest market (ran/dollar) in emerging market countries, as well as for the even bigger yen/dollar interbank market in Tokyo. This is consistent with the finding presented in Batten and Bhar (1993) for futures markets. Differently from Jorion's results, however, expected volumes also have a positive, significant effect on volatility in three cases (rupee, shekel and yen).

Table 18 shows the results for regressions that also include expected volatility, measured by the GARCH forecast, among the explanatory variables. The coefficient on unexpected turnover remains positive and statistically significant in most cases. This is in line with the results presented in Jorion (1996). Again, the coefficient on unexpected trading volume it is negative but not statistically significant for the Mexican peso and the real. In these cases only, the GARCH volatility forecast is also significant.

Overall, the results support the idea that the arrival of new public information drives the positive correlation between volumes and volatility, as postulated by the mixture of distribution hypothesis. Favourable evidence is found for four out of six exchange rates from emerging market countries and for the Tokyo interbank yen/dollar market. These findings appear to be independent of market size. By contrast, the mixture of distribution hypothesis appears not to hold for the Mexican peso/dollar and real/dollar markets.

Trading volumes and bid-ask spreads

Figure 2 highlights that in foreign exchange markets in emerging market countries, bid-ask spreads spiked during times in which volatility sharply increased and turnover fell. While spreads tended to narrow shortly after these episodes, in some cases they remained wide for some time. Table 14 shows that in foreign exchange market in emerging market countries, spreads and volatility are positively correlated. In most cases spreads and trading volumes are negatively correlated, a result that contrasts with findings of the early literature.[14] By contrast, the behaviour of spreads appears totally unrelated to changes in volumes and volatility in the Tokyo yen/dollar interbank market, as indicated by correlation coefficients close to zero.

[14] See eg Glassman (1987).

Models that explain bid-ask spreads in terms of inventory costs establish a link between bid-ask spreads, volatility and trading volumes. One determinant of inventory costs is the cost of maintaining open positions, which is positively related to price risk (Jorion (1996)). According to this view, exchange rate volatility increases price risk and thereby pushes up spreads. Supportive evidence is provided by Bessembinder (1994), Bollerslev and Melvin (1994) and Hartmann (1999), who found a positive correlation between spreads and expected volatility measured by GARCH forecasts.

A second determinant of inventory costs is trading activity. Trading volumes can have a different impact on spreads depending on whether they are expected or unexpected. Expected trading volumes should be negatively correlated with spreads if they reflect economies of scale and are associated with higher competition among market makers (Cornell (1978)). By contrast, unexpected trading volumes should have a positive impact on spreads to the extent that they are associated with higher volatility through the mixture of distribution hypothesis.[15]

To test these assertions, I regressed bid-ask spreads on the GARCH variance forecasts and measures of expected and unexpected trading volumes:

(3) $$S_t = \alpha + \beta_1 h_{t+1} + \beta_2 E_{t-1}(v) + \beta_3 [v_t - E_{t-1(v)}] + \beta_4 w_t + \varepsilon_t$$

The results are presented in Table 19. Consistently with the findings of the literature, the coefficient on the GARCH variance forecast is positive and statistically significant, suggesting that volatility influences bid-ask spreads through its effect on inventory costs. However, in contrast to the predictions of the theory, I do not find positive and significant coefficients on unexpected volumes. The coefficients on expected volumes are also not statistically significant. This latter result is not surprising, since the sample period is likely to be too short to allow for changes in these foreign exchange markets that lead to more efficient trade processing and higher competition among market makers.

5. Conclusions

This paper tried to provide a contribution to the literature on the microstructure of foreign exchange markets by investigating the empirical relationship between trading volumes, volatility and bid-ask spreads. Until now most of the research in this area has relied on data on futures markets, since good data on turnover in foreign exchange markets were not easily available. One important critique of this approach is that volumes in futures markets are not representative of total foreign exchange market activity. This paper uses a new data set that includes daily data on trading volumes for the dollar exchange rates of seven currencies from emerging market countries, the Indonesian rupiah, the Indian rupee, the Mexican peso, the Brazilian real, the Colombian peso, the South African rand and the Israeli shekel. To allow a comparison with other studies, it also looks at trading volumes from the Tokyo interdealer yen/dollar market. The data set covers the sample period from 1 January 1998 to 30 June 1999.

An important result is that unexpected trading volumes and volatility are positively correlated, suggesting that they both respond to the arrival of new information, as the mixture of distributions hypothesis predicts. This is consistent with the findings of the literature that relies on futures data. It suggests that the observation that futures markets are not representative is not “damaging” (Dumas (1996)). The markets for the Mexican peso and the real, however, provide important exceptions. In these two cases, the relationship between unexpected volumes and volatility is negative but not statistically significant. Moreover, for the Mexican peso data from foreign exchange market and from futures market give opposite results, as unexpected futures volumes and volatility are positively correlated.

I also find evidence of a positive correlation between volatility and spreads, as suggested by inventory cost models. This result is also consistent with the findings of the literature. However, in contrast to previous studies I do not find evidence of a significant impact of unexpected trading volumes on spreads.

[15] See Jorion (1996).

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6. Tables and Graphs

Table 1

Exchange rate regimes, 1998–99

Currency	Exchange rate regime
Colombian peso	Managed floating within an intervention band
Mexican peso	Independent float
Rand	Independent float
Real	Managed floating within an adjustable band against the US dollar (mid-1995 to January 1999)
Rupee	Independent float
Rupiah	Free float (since the crisis in July 1997)
Shekel	Managed with respect to a basket of currencies, with margins of fluctuations of +/– 15%.[1]

[1] The shekel is fully convertible since May 1998.

Source: IMF Exchange Rate Arrangements and Restrictions, 1999.

Table 2

Summary statistics for the exchange rates levels

	Mean	Std. Dev.	Min	Max
Colombian peso	1486.19	116.28	1305.83	1752.18
Mexican peso	9.33	0.66	8.03	10.65
Rand	5.73	0.51	4.88	6.62
Real	1.36	0.3	1.12	2.19
Rupee	41.75	1.41	38.3	43.52
Rupiah	9614.66	2193.46	6000	16745
Shekel	3.89	0.24	3.55	4.37
Memo item: Yen/dollar	126.80	9.38	108.80	147.25

Notes: The sample period is 1 Jan. 1998 - 1 July 1999.

Table 3

Summary statistics for the percentage changes of exchange rates

	Mean	Std. Dev.	Test mean=0	Skewness	Kurtosis	Min	Max
Colombian peso	0.09	0.59	2.77 (0.01)	2.42 (0)	21.34 (0)	– 1.9	5.55
Mexican peso	0.04	0.76	1.07 (0.28)	1.1 (0)	6.15 (0)	– 2.94	4.49
Rand	0.06	1.05	1.14 (0.25)	– 1.33 (0)	17.14 (0)	– 8.88	4.58
Real	0.13	1.4	1.78 (0.08)	1.39 (0)	28.15 (0)	– 10.77	11.41
Real (1.1-1.7.1999)	0.32	2.4	1.49 (0.1)	0.58	7.59	– 10.77	11.41
Rupee	0.03	0.29	1.81 (0.07)	– 0.24 (0)	20.3 (0)	– 2.13	2.01
Rupiah	0.14	4.24	0.67 (0.05)	1.05 (0.06)	7.84 (0)	– 18.47	22.6
Shekel	0.04	0.5	1.5 (0.14)	1.08 (0)	7.4 (0)	– 2.25	2.87
Memo item: Yen/dollar	– 0.02	1.02	– 0.29 (0.8)	– 1.00	5.57	– 6.6	3.3

Notes: The sample period is 1 Jan 1998 - 1 July 1999.

Table 4
Sample autocorrelation coefficients

	1	2	5	10	20	60
Colombian peso						
exchange rate	0.18	0.02	– 0.04	0.04	– 0.01	– 0.05
volume	– 0.25	– 0.06	– 0.1	0.0	0.03	0.08
bid-ask spread	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
number of deals	– 0.24	– 0.02	0.03	0.0	0.05	0.06
Mexican peso						
exchange rate	– 0.03	0.02	0.02	0.09	0.06	0
volume	– 0.11	– 0.03	0.01	0.01	– 0.04	– 0.01
bid-ask spread	– 0.21	– 0.02	0.01	0.02	– 0.02	– 0.1
Rand						
exchange rate	– 0.003	– 0.04	0.21	0.09	– 0.08	0.009
volume	– 0.18	– 0.24	0.13	0.15	0.09	0.1
bid-ask spread	– 0.03	– 0.004	– 0.01	0.05	– 0.01	– 0.005
Real						
exchange rate	0.15	0.16	– 0.11	0.11	– 0.01	– 0.03
volume	– 0.18	0.01	– 0.09	0.11	0.23	0.04
bid-ask spread	– 0.08	0.39	– 0.05	0.005	– 0.02	– 0.02
Rupee						
exchange rate	0.03	0.00	– 0.02	0.023	0.01	– 0.07
volume	– 0.00	– 0.00	– 0.00	– 0.00	– 0.00	– 0.00
bid-ask spread	– 0.15	0.20	0.05	0.03	– 0.02	– 0.02
Rupiah						
exchange rate	0.16	0.04	0	0.06	0.04	0.01
volume	– 0.4	0.12	0.09	– 0.15	0.04	– 0.01
bid-ask spread	– 0.01	– 0.004	– 0.004	– 0.005	– 0.004	– 0.002
Shekel						
exchange rate	0.12	0.2	– 0.02	0.13	– 0.05	0.03
volume	– 0.15	– 0.01	0.22	0.08	0.02	0.18
bid-ask spread	– 0.38	0	– 0.08	0.09	– 0.04	0.04
Memo item: Yen/dollar						
exchange rate	0.14	0.005	– 0.02	0.03	0	0.05
volume	– 0.29	– 0.06	0.21	0.15	0.06	0.02
bid-ask spread	– 0.37	– 0.08	0.09	0.05	0.07	0.02

Notes: The sample period is 1 Jan 1998 - 1 July 1999. All variables are expressed in percentage changes. Historical volatilities are computed with daily data over rolling windows of 20 business days. Bid-ask spreads are expressed as percentage of the exchange rate.

Table 5

Summary statistics for the 1-month historical volatility

	Mean	Std. Dev.	Min	Max
Colombian peso	7.94	4.66	1.64	21.97
Mexican peso	10.53	5.83	3.28	27.3
Rand	13.11	10.2	2.09	49.2
Real	10.98	18.24	0.56	76.15
Real (1.1.-1.7.1999)	30.54	20.69	6.61	76.15
Rupee	3.73	2.75	0.69	10.66
Rupiah	55.47	38.85	8.35	175.26
Shekel	6.55	4.08	2.09	21.2
Memo item: Yen/dollar	15.33	5.51	7.76	32.46

Notes: Sample period: 1 Jan. 1998 - 1 July 1999. Historical volatilities are computed with daily data over rolling windows of 20 business days.

Table 6

Test for ARCH effects for the percentage change of the exchange rate

Lags	1	2	5	10
Colombian peso	0.00	0.03	0.44	11.77**
Mexican peso	16.25**	21.18**	83.95**	83.8**
Rand	8.1**	9.73**	59.16**	75.56**
Real	15.69**	15.35**	24.33**	40.3**
Rupee				
Rupiah	16.82**	23.89**	67.72**	46.27**
Shekel	25.3**	71.2**	74.13**	75.6**
Memo item: Yen/dollar				

Notes: The table reports results for Engle's (1982) Lagrange multiplier-type test of time-varying heteroschedasticity regression residuals. The test statistics are reported for different lags (1 to 30). ** = the test statistic is significant at the 1% level, suggesting the rejection of the null hypothesis of no ARCH effects.

Table 7

Regressions of volatility on a linear trend

	Constant	Time	Dummy	R^2
Colombian peso	– 0.63* (– 1.94)	0.001** (3.69)	– 0.09 (0.72)	0.01
Mexican peso	0.45 (0.98)	0.00 (0.30)	– 0.06 (– 0.39)	0.01
Rand	2.74* (1.94)	– 0.001 (– 1.34)	– 0.54 (– 1.55)	0.01
Real (1)	– 11.95** (– 4.14)	0.01** (4.02)	– 1.02 (– 1.19)	0.02
Rupee	0.60** (3.00)	– 0.00** (– 2.76)	0.06 (0.89)	0.03
Rupiah	177.22** (4.94)	– 0.16** (– 4.81)	– 4.38 (– 0.86)	0.11
Shekel	0.13 (1.01)	0.0001 (0.90)	0.03 (0.41)	0.01
Memo item: Yen/dollar	1.18* (1.93)	– 0.00 (– 0.15)	– 0.31 (– 1.42)	0.01

Notes: Regressions of volatility, computed as squared returns, on a linear time trend over the sample period 1 Jan 1998 - 1 July 1999. T-statistics are in parentheses. Trading volumes are expressed in US$ millions. (1) Sample period 1.1.1999-1.7.1999.

*,** = significantly different from zero at the 5% and 1% level, respectively.

Table 8

Summary statistics for FX trading volumes

	Mean	Std. Dev.	Min	Max
Colombian peso: Trading volume	165	72	16	362
Colombian peso: Number of trades per day	231	102.7	29	452
Mexican peso	8827	2281	635	15812
Rand	9535	2410	3432	21568
Real	10849	4090	2671	31219
Real (1)	8153	2549	3051	16965
Rupee	3478	1351	1	8211
Rupiah	1072	250	611	1871
Shekel	772	244	5	1698
Memo item: Yen/dollar (3)	12944	4453	1737	41341

Notes: Average daily turnover, in US$ millions. The sample period is Jan 1998 - June 1999. (1) Sample period 1.1.1999-1.7.1999. (2) Number of deals per day. (3) Traded on the Tokyo interbank market. In April 1998, average daily *global* turnover for yen/dollar transactions amounted to US$ 267 billion. Total FX turnover in April 1998 was US$ 1500 billion.

Table 9

Summary statistics for exchange traded volumes

Series	Mean	Std Dev.	Min	Max
Real	16	35	0	277
Real (1)	224	484.27	0	4164
Mexican peso	247	160	0	934
Mexican peso (1)	4632	2968.35	0	17076
Rand	12	22	0	270
Rand (1)	142	275.35	0	3361

Notes: Notional values, in US$ millions. The sample period is January 1998 - June 1999. (1) Number of deals per day.

Table 10

Summary statistics for percentage changes of OTC trading volumes

	Mean	Std. Dev.	Test mean=0	Skewness	Kurtosis	Min	Max
Colombian peso	7.5	45.16	3.17 (0)	2.95	20.17	– 84.02	411.72
Colombian peso (2)	6.97	47.6	2.8 (0)	4.54	38.93	– 81.77	505.71
Mexican peso	12.78	109.09	2.3 (0.02)	10.34	126.58	– 93.04	1542.37
Rand	2.65	26.24	1.6 (0.11)	1.24	4.4	– 64.2	141.19
Real (1)	5.48	38.24	1.6 (0.12)	4.9	38.32	– 73.49	318.59
Rupee							
Rupiah	3.20	27.24	1.2 (0.25)	0.52	-0.13	– 50.27	68.44
Shekel	4.05	30.70	4.6 (0)	7.73	85.99	– 100.00	104.77
Memo item: Yen/dollar (3)	7.98	46.6	3.6 (0)	2.77	13.78	– 78.06	346.88

Notes: The sample period is Jan 1998 - June 1999. (1) Sample period 1.1.1999-1.7.1999. (2) Number of deals per day. Traded on the Tokyo interbank market.

Table 11
Regressions of trading volumes on a linear trend

	Constant	Time	Dummy	R^2
Colombian peso: Trading volume	315.64** (19.43)	– 0.33** (– 9.35)	– 12.70 (– 1.70)	0.27
Colombian peso: Number of trades per day	506.72** (23.41)	– 0.59** (– 13.80)	– 15.93 (– 1.64)	0.44
Mexican peso	11345** (20.94)	– 5.35** (– 4.46)	– 563.28** (– 2.15)	0.07
Rand	12992** (9.25)	– 6.54** (– 2.45)	– 996.28** (– 3.10)	0.07
Real (1)	28454** (16.15)	– 33.83** (– 10.66)	– 223.45 (– 0.47)	0.39
Rupee	6786** (11.79)	– 3.41** (– 6.01)	126.94 (0.90)	0.08
Rupiah	– 296.27 (– 0.54)	2.37** (2.46)	– 3.91 (– 0.07)	0.09
Shekel	127.48** (7.71)	– 0.04 (– 1.25)	17.73* (2.04)	0.02
Memo item: Yen/dollar (3)	18141** (17.21)	– 9.74** (– 4.59)	– 1993** (– 3.46)	0.09

Notes: Regressions of trading volumes on a linear time trend, over the sample period 1 Jan 1998 - 1 July 1999. T-statistics are in parentheses. Trading volumes are expressed in US$ millions. (1) Sample period 1.1.1999-1.7.1999. (2) Number of deals per day. (3) Traded on the Tokyo interbank market. In April 1998, average daily *global* turnover for yen/dollar transactions amounted to US$ 267 billion.

*,** = significantly different from zero at the 5% and 1% level, respectively.

Table 12

Summary statistics for the bid-ask spreads

	Mean	Std. Dev.	Min	Max
Colombian peso	n.a.	n.a.	n.a.	n.a.
Mexican peso	0.12	0.08	0.02	0.94
Rand	0.20	0.63	0.01	12.27
Real	0.16	0.32	0.01	2.68
Real (1.1.-1.7.1999)	0.44	0.44	0.01	2.70
Rupee	0.37	0.23	0.00	2.36
Rupiah	2.11	1.49	0.14	8.70
Shekel	0.29	0.16	0.12	1.18
Memo item: Yen/dollar	0.05	0.02	0.02	0.09

Notes: Sample period: 1 Jan 1998 - 1 July 1999. Bid-ask spreads are expressed as percentage of the exchange rate. The data source is DRI.

Table 13

Summary statistics for the percentage changes of bid-ask spreads

	Mean	Std. Dev.	Test mean=0	Skewness	Kurtosis	Min	Max
Colombian peso	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Mexican peso	18.44	87.47	4.15 (0)	4.15	4.15	– 84.9	853
Rand	34.4	401.6	1.68 (0.1)	18.55	357.1	– 97.3	7763
Real	40.4	258.7				– 92.3	3491
Real (1.1.–1.7.1999)	69.57	417.68	1.89 (0.06)	6.71	46.76	– 84.8	3443.98
Rupee	0.03	0.29	1.81 (0.07)	– 0.24 (0)	20.3 (0)	– 2.13	2.01
Rupiah	521.54	7999	1.28 (0.2)	17.5	322.17	– 1056	150148
Shekel	4.07	28.8	2.78 (0)	1	2.31	– 57.3	135.12
Memo item: Yen/dollar	12.9	58.4	4.3 (0)	1.39	2.38	– 70.3	237.1

Notes: Sample period: 1 Jan 1998 - 1 July 1999. Bid-ask spreads are expressed as percentage of the exchange rate.

Table 14
Correlations

	Δxr, volume	**Δ^+xr, volume**	**Δ^-xr, volume**	**|ΔXR|, volume**	**Volatility, volume**	**Hist. vol., volume**	**Δxr, spread**	**Spread, volume**	**Spread, volatility**
Colombian peso: Trading volume	0.08	0.14	0.05	0.08	0.09	0.01	n.a.	n.a.	n.a.
Colombian peso: Number of trades per day	0.13	0.15	0.03			0.13	n.a.	n.a.	n.a.
Mexican peso	0.06	– 0.10	0.17	– 0.11	– 0.10	– 0.28	0.26	– 0.15	0.64
Rand	0.16	0.27	– 0.11	0.20	0.14	– 0.08	0.15	– 0.05	0.14
Real	– 0.17	– 0.42	0.26	– 0.37	– 0.21	– 0.57	0.31	– 0.47	0.56
Real (1.1.-1.7.1999)	– 0.25	– 0.31	– 0.02	– 0.05	– 0.01	– 0.28	0.32	– 0.30	0.35
Rupee	0.10	0.37	– 0.35	0.38	0.28	0.40	0.13	0.38	0.38
Rupiah	– 0.09	0.17	– 0.30	0.21	0.10	– 0.02	– 0.05	– 0.20	0.30
Shekel	0.04	0.30	– 0.27	0.28	0.25	0.09	0.17	0.16	0.43
Memo item: Yen/dollar	– 0.16	0.47	– 0.45	0.45	0.40	0.15	– 0.09	0.08	0.08

Notes: Correlation coefficients are computed for the period 1 Jan 1998 - 1 July 1999. Exchange rate changes are percentage changes; volumes are expressed in logarithms; bid-ask spreads are expressed as a fraction of the spot rate; volatility is computed as squared returns; historical volatility is computed as standard deviations of daily percentage exchange rate changes over rolling windows of 20 business days.

Table 15
Correlations for exchange traded volumes

	Δxr, volume	**Δ^+xr, volume**	**Δ^-xr, volume**	**|ΔXR|, volume**	**Volatility, volume**	**Hist. vol., volume**	**Spread, volume**
Mexican peso	0.09	0.28	-0.11	0.22	0.16	0.04	0.07

Notes: Correlation coefficients are computed for the period 1 Jan 1998 - 1 July 1999. Volumes refer to notional amounts in US$ millions. The other variables are defined as in Table 14.

Table 16

Volatility and trading volume: unconditional regressions

	Constant	Time trend	Volume	R^2
Colombian peso	– 3.86** (– 2.88)	0.0022** (4.16)	0.41* (2.14)	0.02
Colombian peso (2)	– 1.62 (– 0.83)	0.0008 (0.42)	0.23* (2.46)	0.04
Mexican peso	2.89 (1.54)	0.0002 (0.44)	– 0.28 (– 1.58)	0.00
Rand	– 2.11 (– 0.36)	– 0.02** (– 2.75)	2.17* (2.30)	0.06
Real(1)	121.19 (1.75)	– 0.02 (– 1.05)	– 10.80* (– 1.92)	0.07
Rupee	0.21 (1.24)	– 0.001** (– 2.65)	0.05** (2.87)	0.04
Rupiah	20.10 (0.76)	– 0.05 (– 1.80)	5.01** (3.49)	0.07
Shekel	– 1.06* (– 2.68)	0.0002* (2.06)	0.23** (2.75)	0.04
Memo item: Yen/dollar (3)	– 32.18** (– 2.98)	0.0023* (2.45)	3.26** (3.03)	0.12

Notes: Regressions of exchange rate volatility, defined as squared returns, on a constant, a linear time trend and trading volumes (in logarithms) over the sample period 1 Jan 1998 - 1 July 1999. T-statistics based on White's asymptotically consistent standard errors are in parentheses. Coefficients on trading volumes are multiplied by 100. (1) Sample period 1.1.1999-1.7.1999. (2) Number of deals per day. (3) Traded on the Tokyo interbank market.

*,** = significantly different from zero at the 5% and 1% level, respectively.

Table 17

Trading volumes and volatility

	Constant	E(v)	v-E(v)	R^2
Colombian peso	– 4.04 – (2.47)	0.44 (1.91)	0.34* (2.27)	0.02
Mexican peso	3.09 (0.82)	– 0.28 (– 0.78)	– 0.30 (– 1.50)	0.00
Rand	7.50 (0.66)	1.31 (0.98)	3.08* (2.47)	0.07
Real (1)	69.93 (1.04)	14.28 (1.26)	– 2.83 (– 0.62)	0.15
Rupee	– 1.70** (– 2.74)	0.29** (3.16)	0.04** (2.91)	0.05
Rupiah	17.41 (0.41)	5.32 (1.19)	4.97** (2.96)	0.07
Shekel	– 2.63** (– 2.87)	0.56** (2.91)	0.18** (2.65)	0.05
Memo item: Yen/dollar (2)	– 27.27* (– 2.04)	2.78* (2.03)	3.20** (3.06)	0.11

Notes: Regressions of total volatility on a constant, a linear time trend, expected volumes and unexpected volumes. The sample period is 1 Jan 1998 - 1 July 1999. Total volatility is defined as squared returns; log-volumes are decomposed into an expected and unexpected component by using a fitted AR series and its residuals. T-statistics based on White's asymptotically consistent standard errors are in parentheses. (1) Sample period 1.1.1999-1.7.1999. (2) Traded on the Tokyo interbank market.

*,** = significantly different from zero at the 5% and 1% level, respectively.

Table 18

Trading volumes and volatility

	Constant	GARCH	E(v)	v-E(v)	R^2
Colombian peso	– 3.53 (– 1.85)	0.01 (1.03)	0.39 (1.50)	0.34* (2.22)	0.02
Mexican peso	– 0.03 (– 0.01)	0.08** (2.89)	– 0.64 (– 0.18)	– 0.28 (– 1.50)	0.09
Rand	7.19 (0.62)	0.09 (1.66)	0.14 (0.10)	3.04* (2.27)	0.10
Real (1)	– 83.43 (– 0.69)	0.23 (1.73)	20.27 (1.57)	– 1.69 (– 0.36)	0.20
Rupee	– 1.47* (– 2.22)	0.01 (1.06)	0.24* (2.47)	0.04* (2.53)	0.05
Rupiah	17.09 (0.41)	– 0.00 (– 0.08)	5.16 (1.02)	5.00** (2.76)	0.07
Shekel	– 0.90 (– 1.44)	0.08** (3.52)	0.14 (1.02)	0.08 (1.51)	0.19
Memo item: Yen/dollar (2)	– 14.50 (– 1.47)	0.11 (1.90)	1.31 (1.31)	2.93** (3.23)	0.13

Notes: Regressions of total volatility on a constant, a linear time trend, expected volatility, expected volumes and unexpected volumes. The sample period is 1 Jan 1998 - 1 July 1999. Total volatility is defined as squared returns; expected volatility is the one-step-ahead conditional return variance from a GARCH(1,1) specification; log-volumes are decomposed into an expected and unexpected component by using a fitted AR series and its residuals. T-statistics based on White's asymptotically consistent standard errors are in parentheses. (1) Sample period 1.1.1999-1.7.1999. (2) Traded on the Tokyo interbank market.

*,** = significantly different from zero at the 5% and 1% level, respectively.

Table 19

Spreads, trading volumes and volatility

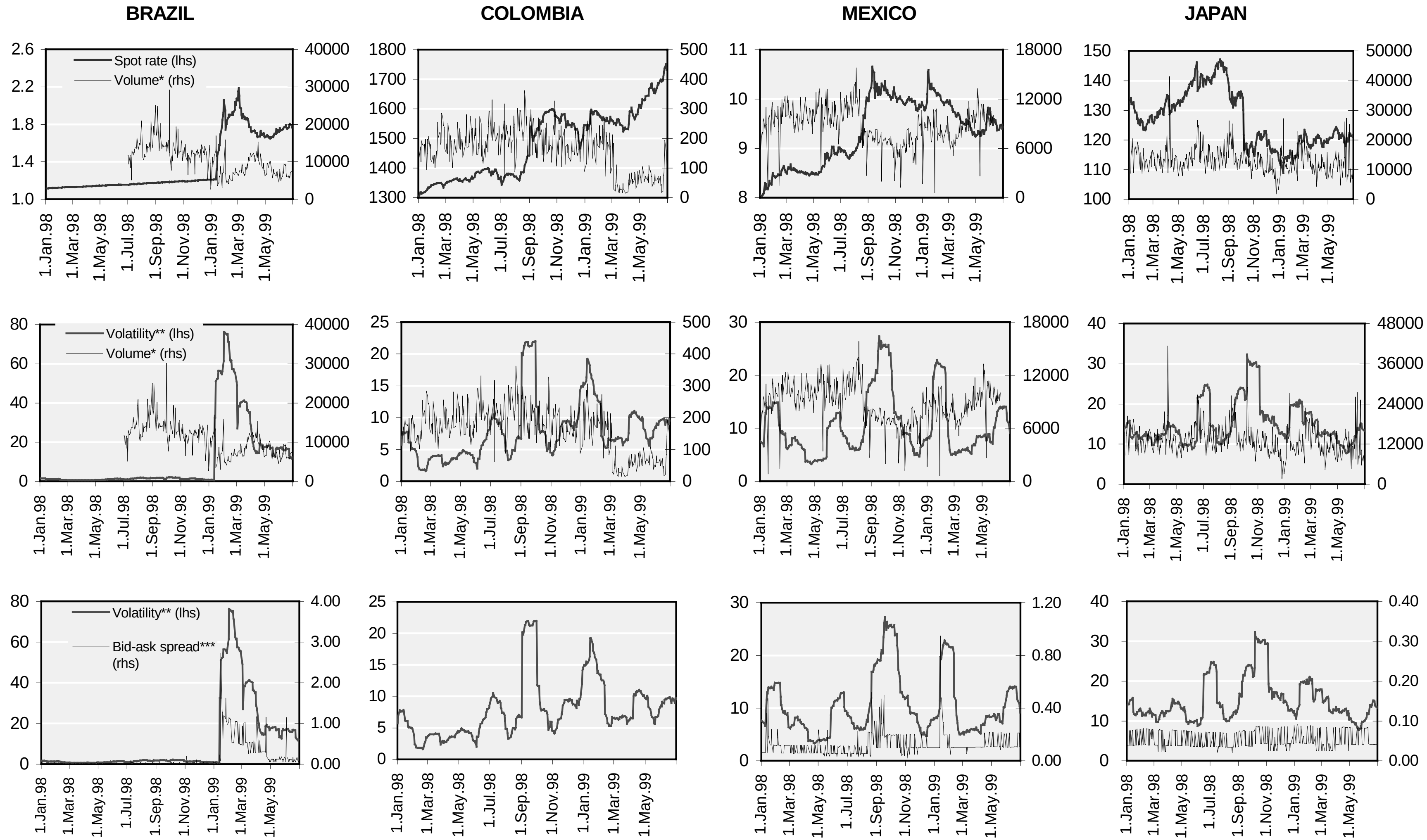
	Constant	GARCH	E(v)	v-E(v)	R^2
Colombian peso	n.a.	n.a.	n.a.	n.a.	n.a.
Mexican peso	0.47** (2.83)	0.01** (5.32)	– 0.05 (– 2.65)	– 0.01 (– 1.21)	0.20
Rand	0.96 (1.42)	0.01 (1.50)	– 0.10 (– 1.45)	– 0.16 (– 1.09)	0.05
Real(1)	– 0.10 (– 0.06)	0.01** (7.31)	0.02 (0.13)	– 0.26 (– 0.99)	0.47
Rupee	0.15 (0.22)	0.03** (6.81)	0.01 (0.16)	0.02 (1.61)	0.22
Rupiah	7.77 (1.73)	0.01* (2.28)	– 1.01 (– 1.55)	– 0.44 (– 1.74)	0.10
Shekel	0.23* (2.13)	0.03** (14.40)	– 0.03 (– 1.42)	– 0.01 (– 0.95)	0.62
Memo item: yen/dollar (2)	0.08 (1.18)	0.00 (1.25)	– 0.00 (– 0.48)	0.00 (0.54)	0.02

Notes: Regressions of bid-ask spreads on expected volatility, expected volumes and unexpected volumes estimated over the sample period 1 Jan 1998 - 1 July 1999. Total volatility is defined as squared returns; expected volatility is the one-step-ahead conditional return variance from a GARCH(1,1) specification; volumes are decomposed into an expected and unexpected component by using a fitted AR(1) series and its residuals. T-statistics based on White's asymptotically consistent standard errors are in parentheses. (1) Sample period 1.1.1999-1.7.1999. (2) Traded on the Tokyo interbank market.

*,** = significantly different from zero at the 5% and 1% level, respectively.

Graph 1

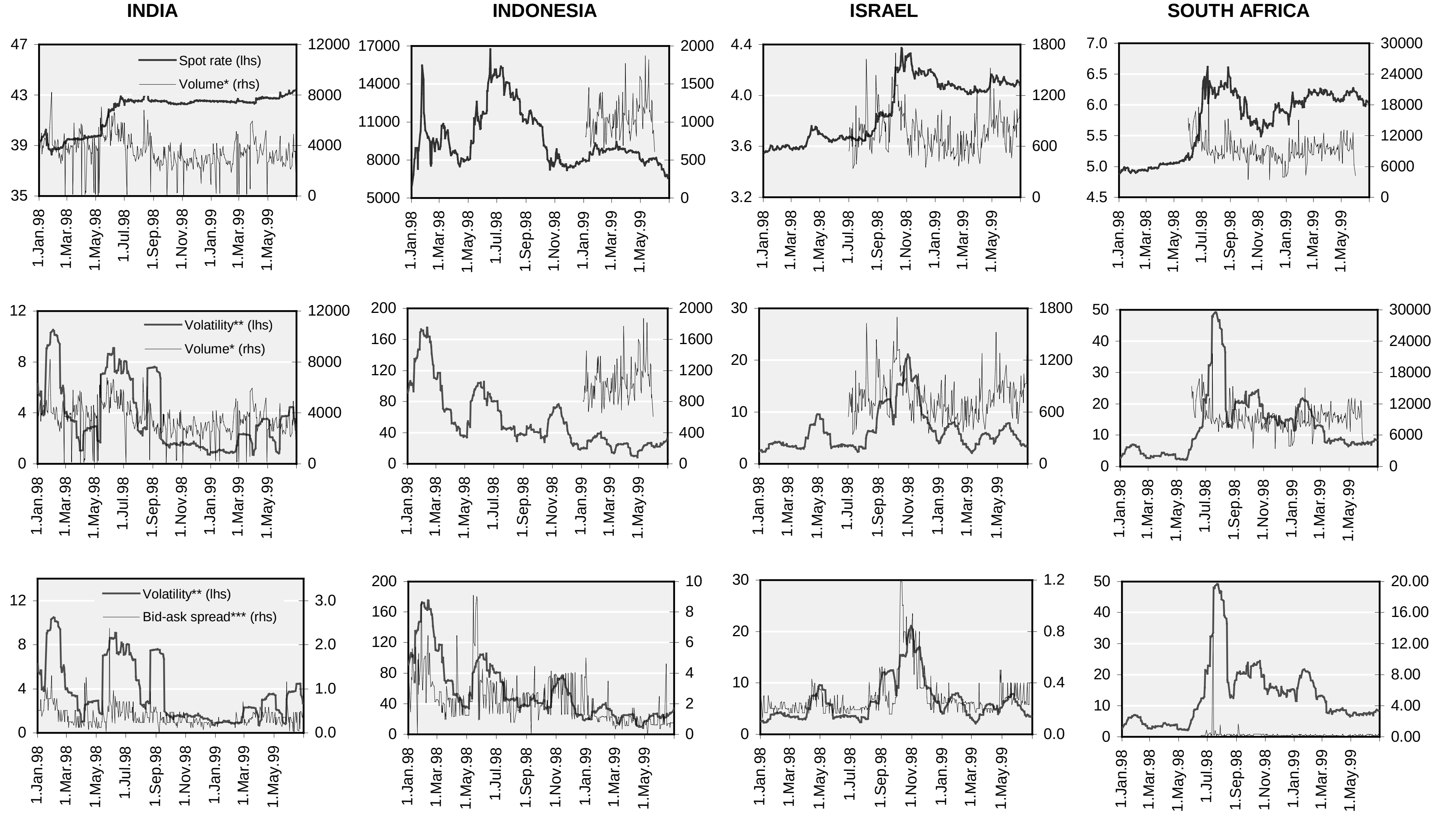
Trading volumes, volatility and spreads



* Expressed in million US$. ** 1-month historical volatility. *** As a percentage of the mid quote.

Graph 1 (continued)

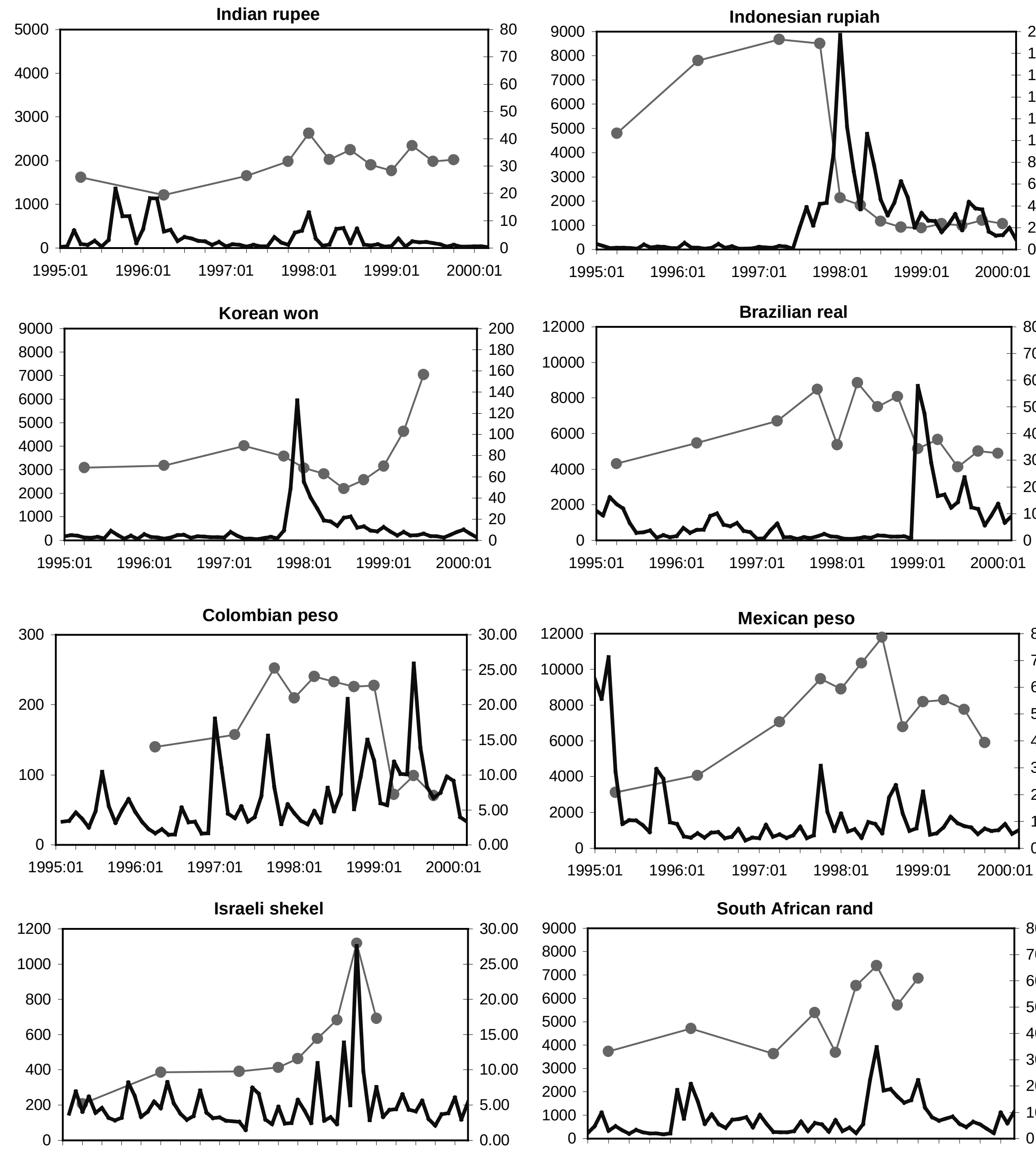
Trading volumes, volatility and spreads



* Expressed in million US$. ** 1-month historical volatility. *** As a percentage of the mid quote.

Graph 2

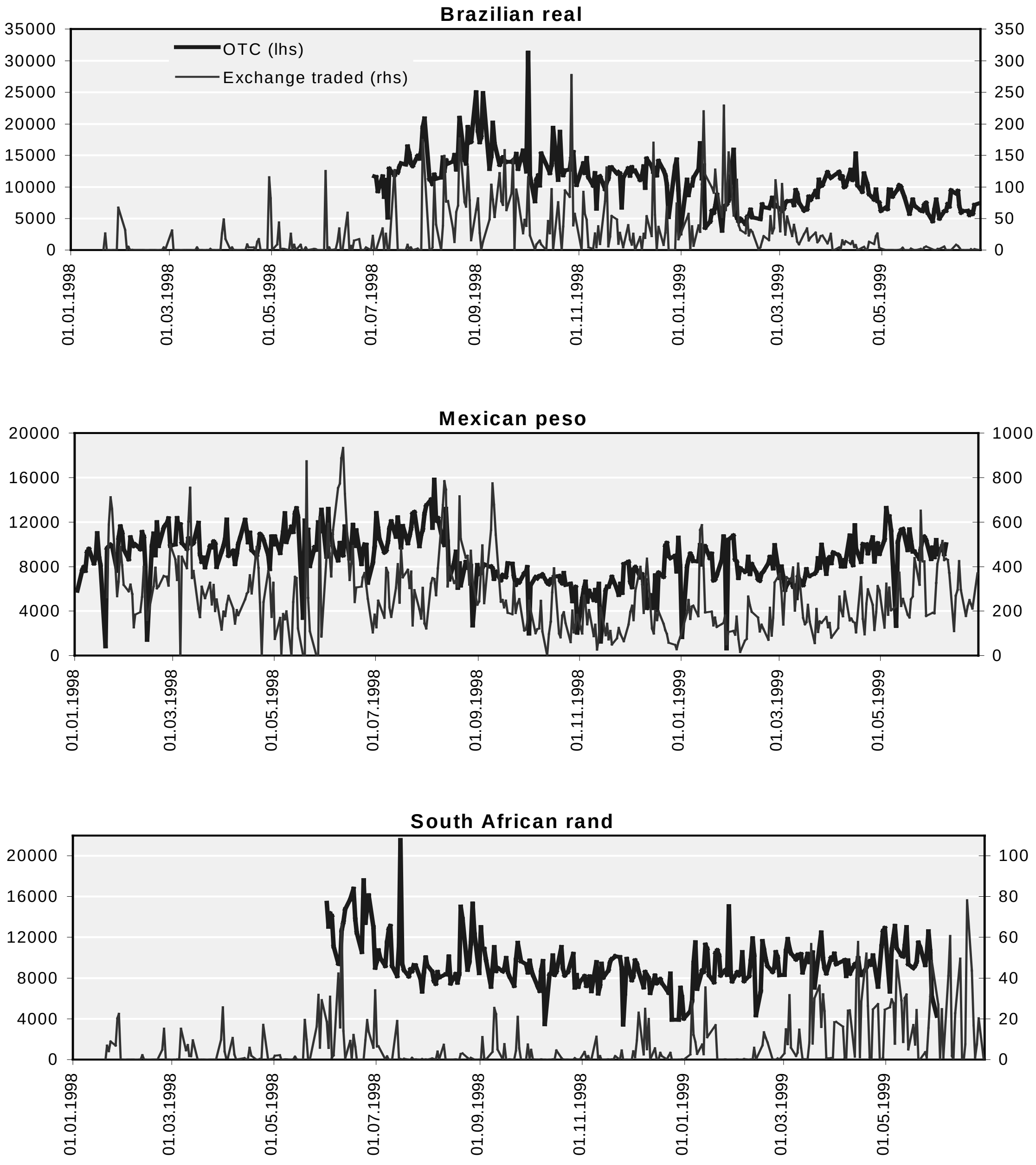
Trading volumes and volatility in selected emerging markets



Notes: Trading volumes refer to local turnover in the domestic currency, per trading day in the month shown (in millions of US$). In the case of Mexican and Brazil, turnover includes other currencies. Volatility is computed as one-month annualised standard deviation of percentage changes in the exchange rate against the US dollar.

Graph 3

OTC and exchange traded foreign exchange market turnover



Notes: OTC turnover is defined as in Graph 1. Exchange traded turnover refers to notional values of futures contracts transacted on the Chicago Mercantile Exchange.

Comments on: "Volumes, volatility and spreads in FX markets: evidence from emerging market countries" by Gabriele Galati

Javiera Ragnartz, Sveriges Riksbank

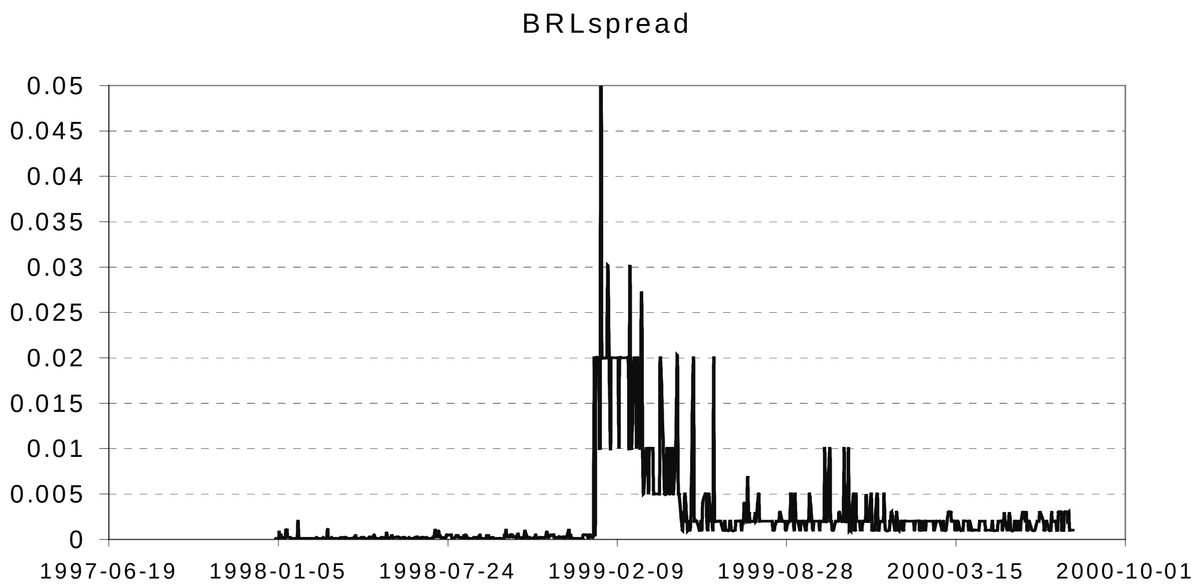
First of all I would like to thank the BIS for arranging this conference and for giving me the opportunity of discussing this great paper. I think the paper covers an area that is interesting for central bankers that try to understand the behaviour and development of exchange rates. The paper contributes to a better understanding of the structure of the currency market.

The paper investigates the relationship between trading volumes, volatility and bid-ask spreads in the foreign exchange markets of seven emerging market exchange rates against the dollar. The yen/dollar exchange rate is also used for comparison purposes. The sample covers June 1998 and the entire year of 1999. Unexpected trading volumes and volatility are found to be positively correlated, with the Mexican peso and the Brazilian real being exceptions. There is also evidence that volatility and bid-ask spreads are positive correlated. However, there is no evidence of a significant impact of trading volumes on spreads. My comments are mainly questions and suggestions to future developments.

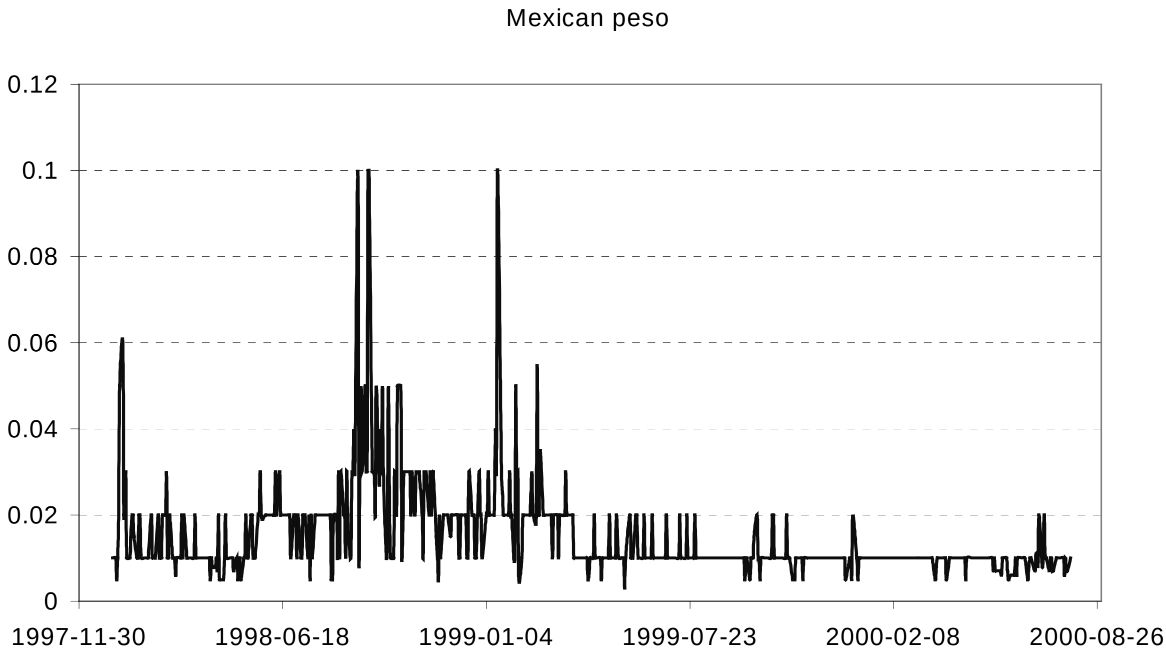
First of all I would also like to ask the author why he thinks the Brazilian real and the Mexican Peso are exemptions. Could it be the case that these exchange rates are more effective than the other markets since these are larger and more heavily traded?

Secondly, I think that the sample period might be too short and more importantly it covers a period characterised by financial stress. The graphs 1a and 1b show that the bid-ask spreads of the Brazilian real and the Mexican peso increased significantly during the fall of 98, a time of high volatility in the currency markets in general following the Russian crisis. However, these spreads decreased significantly in late 99 and have since remained quite stable at a lower level. Thus, there is a possibility that the results might be altered if a longer sample including year 2000 is used.

1a. Bid-ask spreads for the Brazilian real, 1998-01-01—2000-07-30



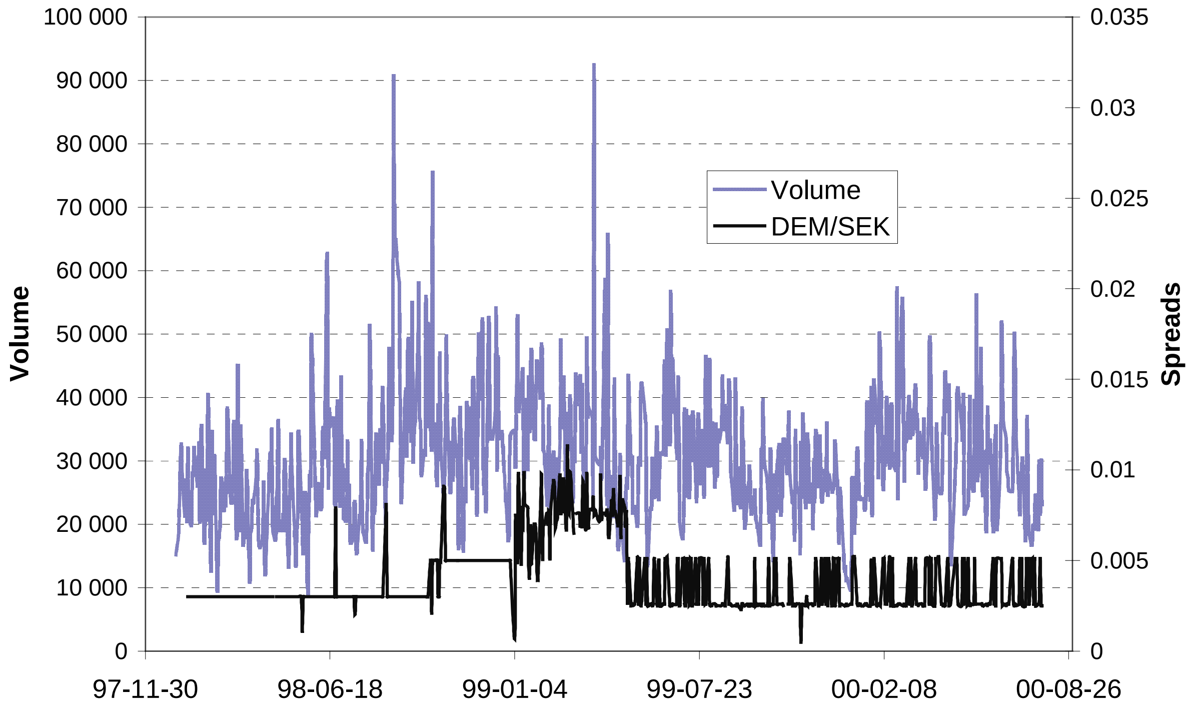
1b. Bid-ask spreads for the Mexican peso, 1998-01-01—2000-07-30



Gabriele Galati uses the Yen/dollar exchange rate in order to compare the results with those of an effective and more liquid market. But the results for the Yen/dollar tend to differ somewhat form the other currency pairs. For instance table 14 in the paper shows that the coefficients tend to be higher for this exchange rate than those for the emerging markets exchange rates. Table 16 shows that the Yen/dollar exchange rate regression tends to have a significantly higher R^2- value. What does the author think is the reason to this? Could the answer be as simple as the Yen/dollar market being more effective?

Finally, I would like to take the opportunity and promote research on the Swedish krona. The Swedish krona behaved quite similar to other emerging market currency during the Asian crisis of 1997 and the following Russian crisis during 1998. It appears that market participants tend to leave the Swedish market during times of financial stress independent if Sweden is affected by the crisis or not. Since the Swedish krona behaves this way it would be nice to see if the same results would be found for the Swedish currency. Graph 2 shows volume and bid-ask spreads on the SEK/DEM exchange rate. The turnover data is not completely clean in the sense that it could include other exchange rates, but should be approximately the SEK/DEM turnover. The graphs show that even though the volume decreased in late 1999 it has once again increased lately. However spreads appears to have been quite constant since the end of 1999.

2. DEM/SEK spreads and volume, 1998-01-01—00-07-30



Comments on "Trading volume, volatility and spreads in FX markets: evidence from emerging market countries" by Gabriele Galati

Alain Chaboud, Federal Reserve System

The nature of the interaction between volume, volatility and the bid-ask spread in foreign exchange markets is still poorly understood, and Gabriele Galati's paper makes excellent use of a new set of transaction volume data to shed light on the subject. The paper provides a test of what has become known as the "mixture of distributions hypothesis," which predicts that trading volume and volatility, simultaneously driven by the arrival of information, should be positively correlated. Using data for seven currencies of large emerging market economies, the paper offers support for that prediction, with the important exceptions of the Brazilian real and the Mexican peso. It also finds a positive correlation between volatility and bid-offer spreads, in line with inventory cost models. I offer a few remarks on the analysis of the link between volume and volatility, and briefly touch on the subject of foreign exchange turnover data.

The study of the correlation between volatility and volume in this paper is rendered more interesting, but perhaps also more difficult, by the sample period of the study, 1998 and 1999, during which the financial markets of many emerging economies experienced turmoil. In that light, the failure of the Brazilian and Mexican currency markets to show a positive correlation between volume and volatility is not altogether a surprise. It may not be much of a stretch to think that volatility and volume could exhibit a positive relation only up to a certain level of volatility, with the correlation becoming negative as volatility grows so large that many investors withdraw from the particular market. The predictions of the mixture of distributions hypothesis model would then be realised in "normal" market conditions, but not in turbulent market conditions. This (unproven) scenario may be easier to swallow for the case of emerging market currencies than for major currencies, but the sharp movement of the dollar/yen exchange rate in October 1998, reportedly accompanied by (likely in part caused by) thin market conditions, is one recent example of this type of phenomenon occurring in a major market. One could perhaps then interpret positive correlation between volume and volatility as a sign of a "healthy" or liquid markets, while the presence of negative correlation between volume and volatility could be taken as a symptom of inadequate liquidity. If such a non-linear relationship exists between volatility and volume, simple linear regression techniques may not be fully adequate for proper inference, and, given the interesting results in the present paper, this may constitute a good opportunity for further research.

As is commonly done, the volatility measure used in this paper is based on net daily changes in exchange rates, matching the daily frequency of the turnover series. While this may appear to be a virtue, it would perhaps be preferable to use a volatility measure that better reflects the cumulative amount of price movement over the trading day and not just the net movement. This would be more in the spirit of the mixture of distributions hypothesis, where the arrival of each new piece of information results in both trading activity and movement in the price. With the daily turnover data representing the sum of all trading activity, matching them with a cumulative measure of price movement would avoid a case where, for instance, two salient pieces of news on the same day moved the exchange rate sharply but in opposite directions, yielding both a high trading volume and a misleadingly low measure of volatility. As an alternative measure of volatility, one could use the daily sum of absolute five - minute exchange rate movements, or some other estimate of integrated volatility. If high-frequency price data are unavailable, using the daily high-low range instead of the daily return as a measure of volatility has been shown to be a step in the right direction.

In a very interesting aside, the paper reports extremely low correlation coefficients between turnover in three of the domestic spot markets in the study and corresponding futures markets turnover from the Chicago Mercantile Exchange. Though the correlation coefficients may be affected by the very low liquidity of those particular futures contracts, this finding still raises a (large red) flag, as currency futures turnover data have been widely used as a proxy for spot turnover data. For spot currency markets, over-the-counter and highly decentralised, transaction volume data for most currency pairs have generally been very difficult if not impossible to obtain. Several researchers have displayed great ingenuity and patience in assembling data sets such as the one in this study, but all these data have been limited in time and scope. The widespread use of electronic trading for most interdealer transactions in recent years carries with it hope that comprehensive high-frequency transaction data for most major currency pairs may soon be available for research.