Currency Crises, (Hidden) Linkages, and Volume•

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Abstract

The conference presentation was based on Bruche et al (2006) who study contagion in foreign exchange markets in the post-Asian crisis era. They develop a factor model specific to foreign exchange markets, where a key explanatory variable is foreign exchange trading volume. They find that their model identifies crisis episodes where volume has significant explanatory power. This suggests that trading volume would be an important variable policy makers should monitor in their analysis of currency crisis.

• We thank the discussant and the conference audience for excellent comments and suggestions. All errors are our responsibility. This paper, and subsequent updates can be downloaded from out website, www.RiskResearch.org. This paper is based on the conference presentation and summarizes the results in Bruche et al. (2006). Corresponding author Jon Danielsson, *j.danielsson@lse.ac.uk*. The views expressed in this article are those of the authors and do not necessarily reflect those of the BIS.

Introduction

The transmission of shocks across countries via the currency markets – both for fundamental as well as for seemingly unexplained reasons – is an important concern for policymakers. While financial globalization has been the catalyst for significant economic benefits, it also has the potential to increase the likelihood of spillovers of market turbulence and uncertainty across countries. These may occur even between countries that do not share any obvious close linkages, such as geography, trade, or development levels. An extensive body of literature has documented country linkages via capital markets, most prominently during the Asian crisis. Considerable anecdotal evidence of contagion in foreign exchange markets exists, which has attracted considerable attention by policy makers and market analysts. Nonetheless, formal analysis of such events has been relatively scarce compared to contagion in equity markets. This lack of formal modelling provides the motivation for our work. We propose two extensions to the extant literature on contagion. First, we extend and adopt extant contagion models to currency markets. Second, we introduce foreign exchange market turnover, or volume, as a key variable to capture country linkages.

A number of models of contagion have been proposed in the literature, most of which where developed with the Asian crisis of 1997 in mind.[1] Tests for contagion are frequently based on changes in correlations, where the significance of the test statistic is adopted to allow for asynchronous volatility levels. As argued by Bruche et al (2006), some common tests lack robustness for small sample sizes and are therefore unable to recognize contagious episodes unless the change in correlations is unrealistically large or the contagious episode is long-lasting. While this may not be a concern in episodes such as the Asian crisis in 1997, currency crisis typically tend to be short lived, lasting often days or weeks rather than months, and thus are too short for most available tests. Consequently, applying these techniques might lead to a possibly erroneous conclusion of interdependence rather than contagion.

Bruche et al (2006) propose an extension of the literature in two main directions. First, they develop a factor structure specific to currency markets, by adopting extant models to currency markets. Second, they consider the specific importance of trading volume for currency trading, both during tranquil and crisis periods. This enables them to document linkages in currency markets based on both price and quantity movements.

Their model is in part motivated by the extensive research on informational asymmetries in foreign exchange markets, such as the market microstructure models of Lyons (2002). In such a context, linkages may arise e.g. through trading activity by hedge funds and proprietary trading desks of commercial banks whose portfolios span many emerging market countries. As a result, when embedded within a contagion model, trading volume has the potential to provide useful information on a number of issues important to policy

1 Surveys of this literature can be found in e.g. Claessens et al (2001), Forbes and Rigobon (2001), Moser (2003) and Classens and Forbes (2004). See e.g. Forbes and Rigobon (2002), Corsetti et al. (2005) and Dungey et al. (2005) for specific models.

makers, such as the identification of fragility, examination of crises and near-crises, identification of cross-country linkages, and in particular the danger of contagious failure. One possible channel, which has received much attention recently, is the spreading of market pressure through the unwinding of carry trade position held in different currency markets. The focus of the paper is on the relationship between volume, volatility and liquidity, and in particular on how it changes during times of stress.

One important innovation is the augmentation of factor models of contagion with publicly available data with a unique data set on foreign exchange trading volumes that a selected number of central banks has made available to the BIS. Since foreign exchange trading volume is generally not publicly available, it can have a first moment effect on exchange rates even in a context of efficient markets. The information content of this variable might be important for example in cases where the central bank's activity in the foreign exchange market prevents – at least temporarily – speculative pressure from being reflected in sizeable exchange rate changes. In such a case the various moments of the distribution of exchange rates may fail to reveal important changes in market conditions and linkages across markets.

Considering the considerable literature on contagion during the Asian crisis, Bruche et al (2006) elect to focus on currency crisis and contagion only after the Asian crisis. Their sample starts in 1998, and thus importantly includes the Russia and LTCM crises and their repercussions during 1998.

Bruche et al (2006) sidestep the issue of the causes of currency crisis, such as the realization of underlying macroeconomic weaknesses. Rather, they confine the attention to identifying linkages between financial markets, regardless of whether they arise from fundamentals. In fact, a key part of the approach is to attempt to understand linkages between currency markets where, at least superficially, fundamentals do not indicate strong linkages between the underlying economies. In the context of financial markets that are integrated across the globe, apparently unrelated markets may be linked through their role in international investors' portfolios. The spreading of turbulence across markets in 1998 is a striking example of how trading strategies spanning many markets create a fertile ground for contagion. Another, recent example is the widely reported transmission of market pressure from Iceland to a number of emerging markets in early 2006, which, given the relatively small size of Iceland's economy, can hardly reflect fundamental induced linkages. Market commentary suggested that one mechanism for spreading contagion in this episode was the use of carry trades by investors that were simultaneously exposed to multiple emerging market economies. In this case, a loss on one country, or even just uncertainty about possible sizeable future losses, can affect trading decisions on other countries in the portfolio, perhaps through risk limits or margin calls. The recent turbulence in foreign exchange markets highlighted how the sudden closing of carry trade positions can spread quickly and affect currencies around the world.

Bruche et al (2006) find general support for the presence of increased country linkages during high turbulence periods. They find that focusing only on correlation-derived tests

would lead to erroneously reject the presence of contagion in currency markets in most, if not all cases. By contrast, their factor model does identify presence of contagion in some of the crisis periods. By further employing volume as an explanatory variable, they find strong evidence of interlinkages between currency markets, where volume serves as a strong conduit for the transmission of contagion. During tranquil times, volume provides at best weak linkages between countries, but during crisis episodes its impact increases significantly. These linkages exist even in cases where there are no obvious fundamentals linking the countries. One possible underlying mechanism could be the presence of portfolios spanning financial assets from a number of emerging market countries.

Background

A number of approaches for modelling contagion have been proposed in the literature, for a survey see e.g. Claessens and Forbes (2001), Dungey et al. (2003) and Dungey and Tambakis (2003). Contagion is generally considered to be a propagation of a crisis across countries that are not necessarily characterised by geographical proximity, similar economic structures, or trade linkages. There is no agreement, however, on what this means in practice. Eichengreen and et al. (1996) define contagion narrowly as the association of excess returns in one country with excess returns in another country once the effect of fundamentals has been controlled for. A broader definition of contagion centres instead on the vulnerability of a country to events that occur in another country.
Following Claessens and Forbes' (2001) categorization, the literature on the drivers of contagion typically distinguishes fundamental causes and the behaviour of international investors. The former include common shocks (the "monsoonal effect" in Masson (1998), trade linkages (Glick and Rose, 1999) and financial linkages (Goldfajn and Valdes (1997)). The latter include informational asymmetries (Calvo and Mendoza, 2000), liquidity needs (Kaminski and Schmukler, 1999), benchmarking in international portfolios, or changing views on external support to countries in trouble.

The most common approach followed in the empirical literature is to test for the presence of contagion is the testing of changes in the correlation of asset prices across countries (see e.g. King and Wadhwani (1990), Baig and Goldfajn (1999). A common finding is that correlation between markets is higher when volatility increases (see e.g. Ang and Bekaert, 2002, on equity markets).

One variant of this approach consists in analysing correlations or the probability of crisis in country A conditional on fundamentals in country B (eg Eichengreen, Rose and Wyplosz (1996), Glick and Rose (1999), Kaminsky and Reinhardt (2000), De Gregorio and Valdes (2001), van Horen et al (2006)). A significant increase in correlations among different countries' markets, after controlling for the fundamentals, is considered evidence of contagion.

Another variant focuses on the second moment of exchange rates and examines the co-movements in volatility across markets, typically represented by ARCH-type models (see

e.g. Edwards and Susmel, 2001). An alternative line of research has explored comovements across countries during crisis periods defined as extreme events (see e.g. Hartmann et al, 2003, 2006). The idea is that market co-movements may look fairly different when measured far out in the tails, what is known as asymptotic dependence, and such crisis behaviour may not have the same parametric form in different markets. They argue also that focusing on such events is justified since they are severe enough to be always a concern for policy.

Contagion, as defined above, would generally imply an increase in intercountry linkages, which may lead to especially high correlations, at least if we focus on linear dependence. Suppose that a world factor model governs returns. If the volatility of a particular world factor increases, then the returns with the highest exposures to this factor will be more correlated. Furthermore, it is possible that the exposures themselves are dynamic. As exposure increases, so will correlation. Hence giving such a model, one defines contagion in terms of correlation over and above what one would expect from the factor model. In defining contagion this way, Bekaert et al. (2003) find substantial evidence of contagion during the Asian crisis but no evidence of contagion during the Mexican crisis.

As highlighted by several authors, a simple analysis of changes over time in correlation coefficients is fundamentally flawed because it may reflect not just contagion but also the influence of heteroskedasticity (higher volatility raising the co-movement of asset prices), or changes in omitted variables (such as a global shift in the attitude towards risk).[2] Forbes and Rigobon (2002) propose to adjust the test of correlation coefficients for possible changing variance in the crisis country. This typically leads to accepting fewer cases as genuine instances of contagion, since an increase in correlation can now sometimes be attributed to an increase in the variance of the crisis country, while the linear relationship between returns across countries remains stable. Indeed, recent empirical studies on contagion that have estimated changing correlations controlling for the possibility of these other influences (see e.g. Caporale et al. 2005) typically find it more difficult to detect contagion in the data.

The test proposed by Forbes and Rigobon (2002) has been criticized by Corsetti et al. (2005), who argue that one should think about linear relationships between returns across countries in the context of a factor model, which implies that linear coefficients become factor loadings. This also implies that variance in a crisis country can go up either because the idiosyncratic variance of the crisis country has increased, or because the factor variance as increased. If the variance of the factor increases, this has an effect on correlation. By contrast, if the variance of idiosyncratic shocks increases, this has no effect on correlation. Corsetti et al. (2005) argue that Forbes and Rigobon (2002) implicitly assume that all of the increase in variance of the asset returns in the crisis country is due to the increase in factor variance. If this is not the case, then they over adjust the test, meaning that they are too likely to accept the hypothesis of no contagion.

Bruche et al (2006) examine the power of the Forbes and Rigobon (2002) and the Corsetti et al. (2005) tests and find that they have relatively low power in small sample

2 King and Wadhwani (1990) discuss the role of heteroskedasticity but do not correct for it.

sizes. For example, for a crisis of duration of one month, a test with daily data needs an increase in correlation well in excess of 35% for the test to find contagion. A test of contagion in a crisis where the increase in correlation is less than 35% might lead to the erroneous conclusion of interdependence and not contagion.

A different version of this kind of test has been proposed by Dungey et al (2005), who let idiosyncratic shocks in the crisis country affect the return in other countries in times of crisis, instead of allowing for structural breaks in factor loadings.

Identifying crises

The literature has identified several causes for currency crises, such as factors related to domestic macro fundamentals, financial markets, political factors or factors that are unknown. Crises can take a number of different forms: they can arise in a country and remain confined there, or can spread to countries in the same region or countries or countries with similar characteristics. They could also spread to seemingly unrelated countries. A crisis might not appear at first in the behaviour of the spot rate if for example monetary authorities temporarily manage to counter market pressures. A further type of event of interest is that of *near crises*.

One recent example that received much attention among policy markets and market commentary is the attack on the Icelandic krona in February 2006 following the decision of a rating agency to downgrade the outlook for Iceland's sovereign debt. Within a few hours, the Icelandic currency lost some 10% of its value, and pressure spread quickly to currencies of countries such as Hungary, Brazil and New Zealand that had no apparent significant trade or financial linkages with Iceland. Market commentary attributed these spillovers among other things to the way currency trading is set up at major international players, with e.g. one desk covering many countries and doing continuous 24-hour trading or rolling the trading portfolio between desks in different countries.

A key element of our study is the identification of crisis episodes. Our focus is not on identifying shocks that drive financial markets but rather on crisis episodes as periods of high volatility/turbulence/illiquidity in financial markets.

Ideally one would want to endogenously identify crisis episodes within the model. This could be done for example using Markov switching models (see e.g. Fratzscher, 2003), but such tests generally lack robustness. An alternative approach, commonly used in the literature, relies on changes in the statistical characteristics of key variables, such as exchange rate volatility, to identify crisis periods. Such an approach carries with it the danger of circularity, the potential lack of reliability of prices as a crisis indicator, and the risk of data mining. Finally, one can consider macroeconomic variables, news accounts, official reports and the like to identify crisis episodes. The downside of such an approach is that it can only provide a very coarse identification of crisis episodes.

Bruche et al (2006) attempt to avoid these issues by employing a three-level approach which combines anecdotal evidence and press reports, existing event studies and information from commonly used financial indicators. In practice this involved taking crisis episodes from a recent analysis by Calvo et al (2006) and supplementing their analysis with information from other sources such as the IMF World Economic Outlook or the BIS Annual Report.[3] Since these sources in some cases did not provide an identification of crisis dates at the daily frequency, they also examine EMBI spreads for individual countries to pinpoint the exact timing. The start of a crisis would then be identified with the timing of a sudden widening of spreads, whereas the end of a crisis would coincide with the inception of a narrowing trend.

A sample of results from Bruche et al (2006) are presented in Table 1.

Table 1 Crisis episodes

Crisis episode	**Dates**	**Currencies expected to be affected**
Attack on the Colombian peso	16.4.-25.8.1999	BR, MX, CL
Stock market turmoil	21.7.-5.10.1998	All emerging markets
Russian default	17.8.-27.9.1998	All emerging markets
Collapse of LTCM	2-23.9.	All emerging markets
Attack on the Brazilian real	12.1.-29.1.1999	Mainly MX, CL, CO, less so other EMEs
Crisis in Turkey	22.7.-5.10.1998	TR, ZA
Financial crisis in Turkey	29.1.-19.10.2001	TR, ZA
Argentinean default	3.1.-25.6.2002 (or, 3-16.1.2002)	BR, MX, CL, CO
Turbulence in Brazil	12.9.-22.10.2002	CL, MX, CO
Attack on the Icelandic krona	20.2-20.4.2006 20.-22.2.2006	All EMEs

Source Bruche et al (2006),

Models

Bruche et al (2006) propose a two equation factor model at the daily frequency to analyze linkages, where the factors are chosen to take into account specific features of currency markets. For example, the reference currency for all currencies in their study is the US dollar, and hence a shock that decreases the dollar's value across the board will affect all the currencies in the sample simultaneously giving the appearance of linkages. This is especially relevant for countries with relatively stable exchange rates and consequently low exchange rate volatility against the US dollar. Bruche et al. (2006) address this issue by using the euro/dollar exchange rate as a main exogenous factor. Secondly, global

3 An example of an account of crises is given by http://www.bis.org/publ/ar99e3.pdf p.32.

interest rates also affect currency markets and consequently changes in US interest rates are introduced as an additional factor.
Bruche at al (2006) estimate the model pairwise, with a target country (T) and a source country (S), with two equations estimated simultaneously. The first equation obtains returns for the source country, adjusted for factor impacts. The second equation has the target country exchange rate returns dependent on three components: the same factors, lagged source country adjusted exchange rate returns, and possibly volumes for both countries. These models are estimated for both the full sample and crisis periods.

Data

Bruche et al (2006) employ three categories of data, exchange rates, interest rates, and volume. The data is daily observations starting at the beginning of the year 1998 and ending in the middle of 2006.

Data on spot rates are taken from Datastream and collected at 4pm London time. The US interest rate used is the federal funds rate.

Finally, they use a unique set of daily data on turnover of domestic currencies vis-à-vis the US dollar in local markets, or volume in short, which was provided to the BIS. The data set captures spot turnover, with the exception of data for the Mexican peso and the shekel, which also include trading in forwards and swaps. Data from the Triennial Foreign Exchange and Derivatives Markets Survey suggest that offshore trading in these currencies is limited (BIS, 2005). Hence, the volumes used here can be taken as being fairly representative of total trading.

With only one exception (Galati, 2001), this is the first time an empirical cross-country study has been carried out using comprehensive data on foreign exchange market turnover at the daily frequency, where employing a shorter data set he focuses on the relationship between volumes and volatility in individual markets.

The individual markets are characterised by very different levels of average activity. The most active markets were those for the Mexican peso, the Brazilian real and the South African rand. To get an idea of the size of these markets, trading of dollars against one of these currencies on average was slightly less than interbank trading in Tokyo, and about one third of local trading of Canadian or Australian dollars against the US dollar in April 1998.

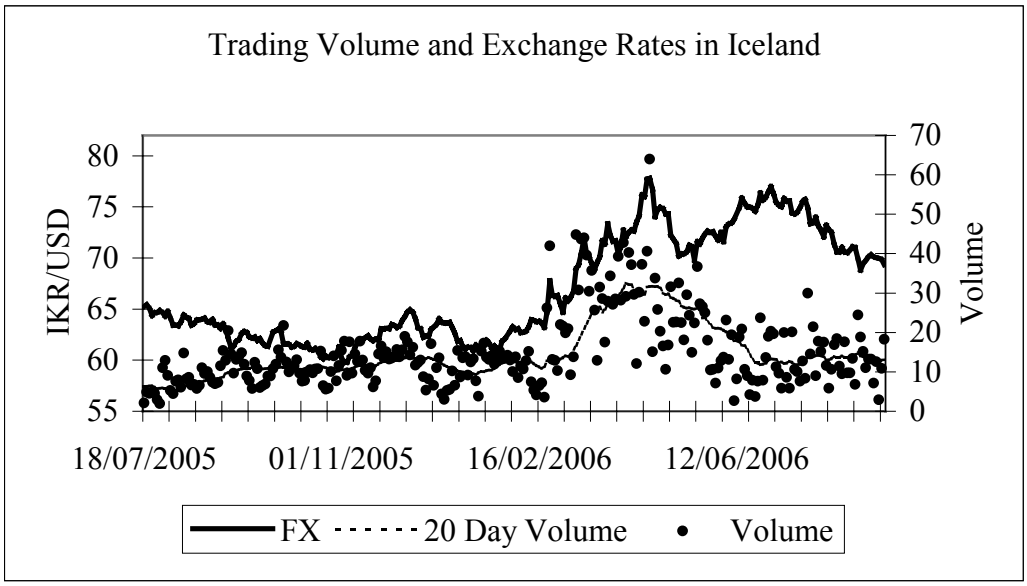
In order to compare the results with foreign exchange markets in industrial countries, and in order to allow a comparison with other studies on trading volumes (Wei, 1994) and Hartmann, 1999), we also used data from the Tokyo interbank market. This data is much less comprehensive. Trading in the Tokyo interbank market accounts for roughly 5% of total yen/dollar trading.

Summary of Results

Bruche et al. (2006) obtain several interesting results, some of which are discussed below. They find that their factor model is more robust in identifying contagious episodes than models employing correlations to identify contagion. One reason is that the factor structure is more robust in small samples than the more correlation-based techniques.

They further find significant improvement in estimates when incorporating volume, where volume induced contagion is as likely to spread from the country in crisis, as volume of other countries affecting the country in crisis.

As an illustration, consider the specific example of the contagious episodes in Iceland in February 2006 which shows exchange rates, daily trading volume, and 20 days moving average trading volume for Iceland from the middle of 2005 to the middle of 2006.



While in the second part of the 2005 there appears to have been a relatively weak link between trading volume and the exchange rates, at the beginning of 2006 trading volume increases sharply along with exchange rates. Volume peaks on April 21 which also corresponds to the day where the krona was weakest. After that volume retreats towards its longer-term trend while the exchange rate remains weak. Similar patterns exist in other crisis episodes. During the crisis in Iceland, the Icelandic volume is partially able to predict exchange rates, both in Iceland and in other countries.

Bruche et al. (2006) generally find that trading volume plays a significant role in currency markets, especially during financial crisis, where the impact of volume is succinctly captured by their factor model. Generally they find that it is necessary to employ a formal model of the impact of volume to accurately account for its role in currency markets.

Conclusion

As this paper has illustrated, the results of Bruche et al (2006) suggest that by employing a carefully crafted factor model it is possible to adopt existing contagion models to the specific problem of contagion in currency markets and currency crisis. By further incorporating trading volume it is possible to clearly identify inter-linkages between countries and thus channels for the transmission of contagious episodes.

Foreign exchange market turnover can help policy makers to identify linkages between markets and understanding the potential of contagious crises. Within the framework discussed in this paper, trading volume appears to be very useful for the daily monitoring of currency markets and the potential contagion of crises.

One interpretation of this role of trading volume is that it captures phenomena such as international investors' strategies that span financial assets of a number of emerging markets. One recent example of such a strategy is carry trades involving several emerging market currencies.

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