DEPARTAMENTO DE ECONOMIA
PUC-RIO

TEXTO PARA DISCUSSÃO
Nº. 420

THE RUSSIAN DEFAULT AND THE CONTAGION TO BRAZIL

Taimur Baig

Ilan Goldfajn

Março 2000

The Russian Default and the Contagion to Brazil

by Taimur Baig and Ilan Goldfajn[1]

March 2000

Abstract

This paper investigates the contagion from Russia to Brazil in late 1998 under two dimensions— players involved and the timing of events. The data does not seem to reflect a compensatory liquidation of assets story by international institutional investors. It does contribute, however, to the suspicion that the contagion was triggered by foreign investors panicking from the Russian crisis, and joining local residents on their speculation against the Brazilian real. Adjusted correlations in the Brady market increase significantly during the crisis, which lends support to the view that if there was a contagion from Russia to Brazil, the most likely place of the transmission was the off-shore Brady market. Finally, the paper does not support the hypothesis that it was the liquidity crisis in mature markets, and not the Russian crisis, that timed the crisis in Brazil.

Table of Contents

I. INTRODUCTION

In the aftermath of the Russian crisis of August 1998, a series of events led to the Brazilian crisis that culminated in the floating of the Real on January 1999. The timing of the events led academic and policy making observers to suspect that there was a contagion from the Russian crisis to Brazil. If true, the transmission of pressure from Russia to Brazil would be somewhat of a special case among the financial crises episodes seen in the 1990s. In contrast to the Mexican (1994) and Thai (1997) crises, the Russian contagion to Brazil appears to have crossed regional borders, leading to a number of interesting questions. Given the lack of substantial trade and direct financial linkages, why did the Russian devaluation prompt capital flight from Brazil? Why did some countries with similar fundamentals and economic links did not have a crisis (as for example Hungary)? In this paper, we attempt to verify the contagion presumption, and analyze related issues that can shed light on our current understanding of financial crises and contagion.

The paper begins from the premise that the Brazilian economy was vulnerable to crisis from its increasing internal and external imbalances, and that it was not pure panic that forced a devaluation of the exchange rate. Subsequently, the paper concentrates on the timing of the crisis. To what extent can the timing of the deterioration in Brazilian financial market variables be attributed to changes in fundamentals or, alternatively, to pure investor panic from the Russian crisis? What was the role of international capital markets in the transmission of the Russian crisis to Brazil? In particular, what was the role of margin calls, on large portfolio managers with Brazilian asset holdings, in this transmission mechanism?

This paper, being a case study, has the advantage of concentrating on a single crisis and its consequences on another single country. This allows us to pull different sources of data to answer the question raised above. The disadvantage is the possible loss of generality if specific Russian and Brazilian characteristic influence our conclusions regarding the contagion mechanism.

The goal of the paper is to examine the contagion from Russia to Brazil under two dimensions. First, we address the timing of the events. In particular, what triggered the run on Brazil, was it the Russian default or the liquidity crisis in the developed financial markets at the time of the Long Term Capital Management (LTCM) crisis? Second, who were the players involved and on what assets the attack was carried out? The answer to this would give us a sense on whether it was mainly foreign (possibly institutional) investors or Brazilian residents that panicked and precipitated the crisis.

The paper is organized as follows: in the next section, we examine the stylized facts regarding both the players and the timing of the events linked to the contagion from Russia to Brazil. In particular, we analyze the claim that as Russian markets tumbled, some large portfolio managers faced margin calls, and in order to balance their portfolio, had to liquidate positions in Brazil. The analysis first scrutinizes the chronology of the events surrounding the Russian devaluation and examines the timing of Brazilian Brady bonds price fall and the

subsequent loss in reserves. Second, we use information on foreign investors and analyze their behavior during the crisis.

In section III, we conduct an econometric exercise to shed light on the extent of fundamentals and contagion-driven movements. We study daily correlations between the Russian and Brazilian equity indices and sovereign spreads, and test for significant change in correlations, taking into account the bias described by Forbes and Rigobon (1999). In addition, we regress changes in financial market variables on variables proxying for fundamentals in each country, and examine the residual correlations between the countries. Finally, in order to estimate the cross-border market pressure and its effect on reserves and sovereign spreads, we use reduced form Vector Auto-Regressions to estimate the impulse response of a fall in Russia's financial prices on Brazilian variables.

The paper concludes that the data does not seem to reflect a compensatory liquidation of assets story by international institutional investors. It does contribute, however, to the suspicion that the contagion from Russia was triggered by foreign investors panicking from the Russian crisis and joining local residents on their speculation against the currency.

Also, the comovement between the financial variables is remarkable, specially with regards to the spreads on Brady bonds where the correlations in the Brady markets are very high and increase significantly (even after adjusting for the bias) during the crisis. This gives support to the fact that if there was a contagion from Russia to Brazil, the most likely place of the transmission was the off-shore Brady markets.

Finally, the paper does not support the alternative hypothesis that it was the liquidity crisis in mature markets that timed the crisis in Brazil and not the Russian crisis.

II.   FROM RUSSIA TO BRAZIL: CONTAGION THROUGH THE FINANCIAL MARKETS

A. Events in Russia

Russia underwent a stabilization process from 1995 onwards, anchored by the policy of maintaining the exchange rate within a band. This policy proved unsustainable as political turmoil and deterioration in the external environment cast increasing doubts on Russia's ability to come to contain its economic fragility. The consequence was a severe financial crisis that erupted in mid-1998, owing primarily to the failure to tackle underlying fiscal problems.

Through 1996-97, Russia continued to incur large fiscal deficits of 7-8½ percent of GDP at the federal level, resulting in a huge increase in its debt burden, particularly at the short term maturity end. In addition, by mid-1998, the external terms of trade had deteriorated by almost 18 percent, year-on-year, due to a drop in international prices for Russia's main exports. The impact of the Asian economic crisis was severe on Russia, as investor withdrawals from emerging markets affected its capital account. Net financing of the

federal government deficit by nonresidents in the form of Eurobonds and ruble-denominated debt declined by 1.8 percent of GDP during July 1997-June 1998, compared with the previous 12-month period.

From late-1997 onwards, domestic interest rates were increased sharply in response to the deterioration in the balance of payments. While the ruble was successfully maintained within its band until mid-August 1998, the absence of decisive fiscal adjustments resulted in large losses of external reserves. Faced with a severe cash-flow problem as investors continued to withdraw from the government debt market and as international reserves dropped precipitously, the authorities announced a restructuring of ruble-denominated government debt and a widening of the exchange rate band in August 1998. The ruble was subsequently allowed to float in early September. The servicing of Soviet-era external debt was halted, and the government initiated talks with creditors for a rescheduling of such debt falling due in 1999-2000.

The domestic impact of these developments was highly unfavorable. A large number of banks that had invested heavily in treasury bills and had extensive foreign currency exposure collapsed, the domestic payment system was temporarily impaired, access to international capital markets was severed, and trade financing was severely disrupted.

The external the crisis was also severe. Investors suffered major losses from both the restructuring of the Russian debt and the devaluation of the ruble. Others were surprised by the fact that it occurred within an IMF program, and panicked regarding other emerging markets.

B. Events in Brazil: suspicion of contagion?

The crisis in Russia set off upheaval in the world financial markets. In Brazil, the effect on the exchange market was extreme. In August and September alone, the excess demand for dollars in the foreign exchange market was 11.8 and 18.9 billion dollars, respectively (see Table 1). The loss of reserves during these months was substantial, and reflected widespread loss of investor confidence on the Brazilian real on the heels of the spectacular collapse of the Russian ruble.

A note on the Brazilian laws and institutions is warranted here. Prior to the Brazilian crisis, the central bank of Brazil was setting an adjustable band for the dollar value of the real, and maintaining a continuing crawling peg within it. There were two foreign exchange markets— the "official," and the "floating" market. The former was intended mostly for transacting proceeds of exports and imports of goods and services, but it had allowed capital account transactions in a number of instances. Notably, large portions of portfolio investment by foreign investors were transacted through this account. These investments were channeled either through two classes of fixed-income funds or through one of the five alternatives established under National Monetary Council Resolution 1289. In the floating market most of the rest of the capital account transactions was transacted, in particular, those made by

Brazilian residents. The Brazilian government would keep the exchange rates on both markets aligned and would not allowed big differences between them.

The data from the official and floating markets offer valuable insights, as they reveal the dynamics of capital flow across foreign domestic investors. Table 1 provides a breakdown of flows in these markets, as well as reserve data during the corresponding periods. Flows data during the months around the Russian crisis reveal that the extent of withdrawals in the official market during the Russian crisis was severe, reflecting withdrawals from foreign investors. Table 1 also provides breakdown of flows data around the Asian crisis, which illustrate as an interesting contrast. Investors to Brazil appear to not have been too concerned during the Asian crisis, as the magnitude of the withdrawals were around the typical range for the market. Their behavior was starkly different in the aftermath of the Russian crisis, as seen in Table 1.

The floating market data, representing domestic investor behavior, had shown sizable withdrawals during the Asian crisis. During the Russian crisis, the outflows were even larger, and fueled by fears from parallel withdrawals in the official markets. The key difference between the impact of the Asian and the Russian crisis on Brazilian markets was that in the latter case official withdrawals took place in a much larger scale. The information obtained from the two separate exchange markets tends to suggest that the withdrawals from foreign investors was a major factor in the exacerbation of the Brazilian crisis. This contributes to the suspicion that the contagion from Russia was triggered by foreign investors panicking from the Russian crisis. The floating market investors, representing Brazilian residents, had jumped ship during the Asian crisis, and repeated the pattern during the Russian crisis, adding further to the pressure in the exchange market.

Figure 1 shows, for the two countries, the movement of spreads on Brady bonds and reserves during 1997-98. The figures shed light on the timing of the events. The co-movement between the variables is remarkable (this is tested formally in section III). It is important to remember than in pegged regimes (or crawling pegs), the appropriate variables to infer pressure are either reserve movements or interest rate levels. The latter are better used when looking at non-policy interest rates, that are more market determined and less influenced by short term objectives of policy makers.

With daily data, one can check the alternative hypothesis that it was the liquidity crisis in mature markets that timed the crisis in Brazil and not the Russian crisis. The Long Term Capital Management (LTCM) crisis surfaced in September 1999,[2] while the Russian default happened a month earlier, on August 17. Figure 2 illustrates movements in two benchmark Brazilian spreads—the C-Bond and IDU. They, along with the flows figure reveal that most of the developments took place immediately after the Russian crisis both in the foreign exchange and the Brady bond markets, although the spreads on the latter market

---

[2] The rescue plan was announced the 23rd of the month.

suffered a new blow during the LTCM crisis (specially the shorter maturity Brazilian IDU bond). The fact that the reaction was initiated a couple of weeks before the LTCM crisis leads us to favor the argument that the Brazilian residents reinforced the speculation once they realized that foreign and institutional investors had joined the capital flight.

Other Brazilian financial variables reflect the Russian crisis with different lags. The floating of the exchange rate occurred only in January, 1999, five months after the Russian crisis. At the beginning, interest policy rate (overnight rate on federal funds - SELIC) was raised to levels close to the ones reached during the Asian crisis, but this time speculation forced the change in the exchange regime (Figure 3).

Table 1. Brazil: Foreign Exchange Market Net Flows, July 1995-November 1999 1/
(In millions of U.S. dollars)

		Floating Rate Market	Official Rate Market	Total Exchange Rate Market	Foreign Reserve Changes
Average July 1995-July 1998		-1,322	2,670	1,348	992
Average August-December 1998		-3,601	-4,326	-7,927	-6,996
Average July 1995-November 1999		-1,593	1,324	62	-198
Asian Crisis	Sep-97	-1,651	613	-1,038	-1,125
	Oct-97	-4,912	-1,039	-5,951	-8,241
	Nov-97	-3,700	-292	-3,992	-1,655
Russian Crisis	Jul-98	-1,839	6,693	4,854	-688
	Aug-98	-2,821	-8,989	-11,810	-2,877
	Sep-98	-8,578	-10,346	-18,924	-21,522
	Oct-98	-2,867	971	-1,897	-3,426

Source: Central Bank of Brazil; and authors' estimates.

1/ Negative sign implies net outflows.

Figure 1. Brazil and Russia: Bond Spreads and Reserves

Bond Spreads, January 1997-December 1998

C-Bond (Brazil)
Eurobond (Russia)

Russian
crisis

Jan-97 Mar-97 May-97 Jul-97 Oct-97 Dec-97 Feb-98 May-98 Jul-98 Sep-98 Dec-98

International Reserves, December 1996-March 1999
(In billions of U.S. dollars)

Brazil (left scale)

Russia (right scale)

Russian crisis

Dec-96 Mar-97 Jun-97 Sep-97 Dec-97 Mar-98 Jun-98 Sep-98 Dec-98 Mar-99
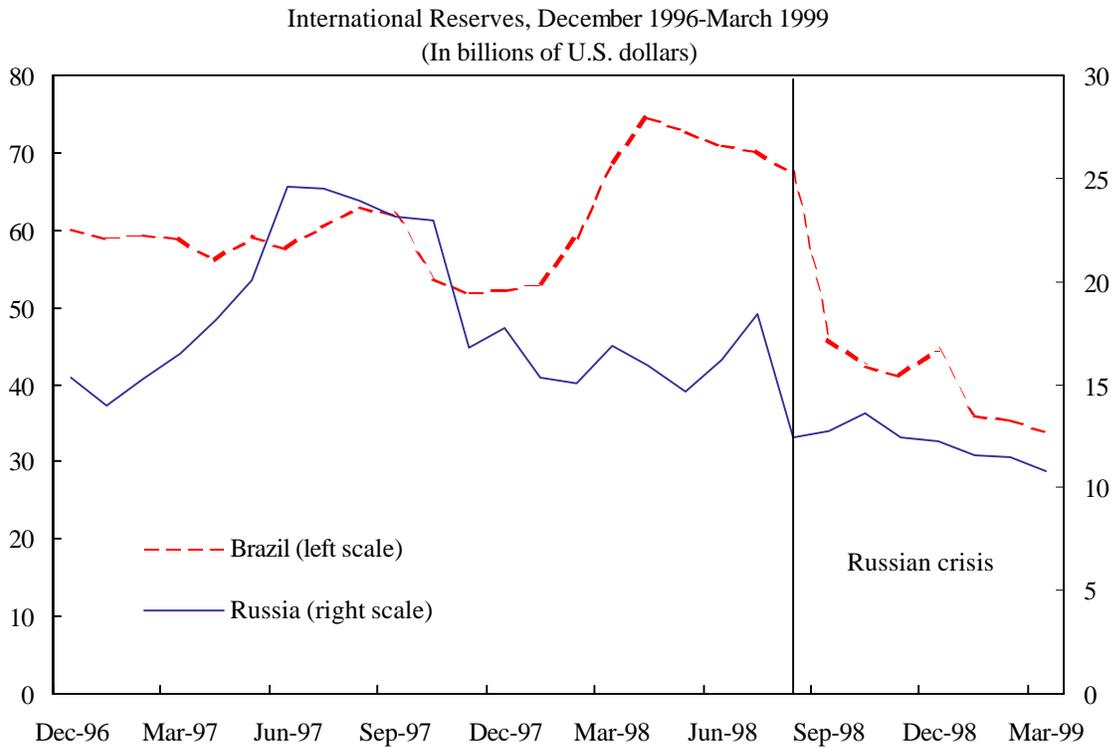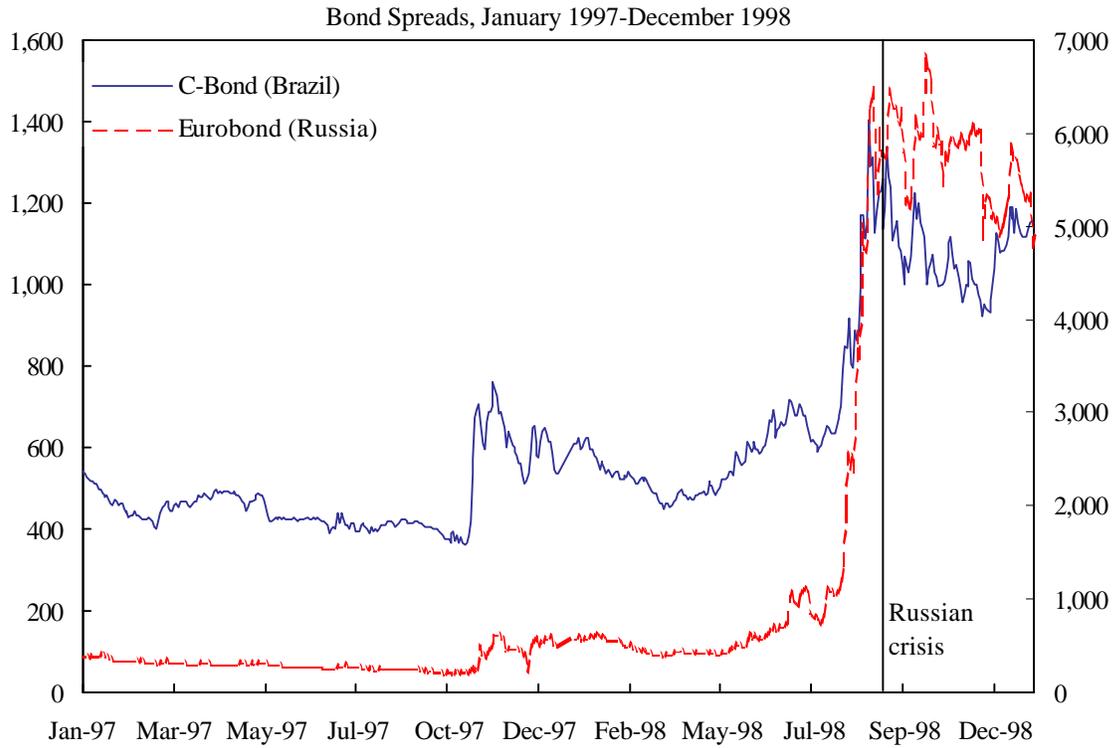
Source: Central Bank of Brazil; and Bloomberg.

Figure 2. Brazil: Brady Bonds and Foreign Exchange Market, August-September 1998

Brady Bonds
(Daily yields)

Foreign Exchange Market
(Daily flows) 1/
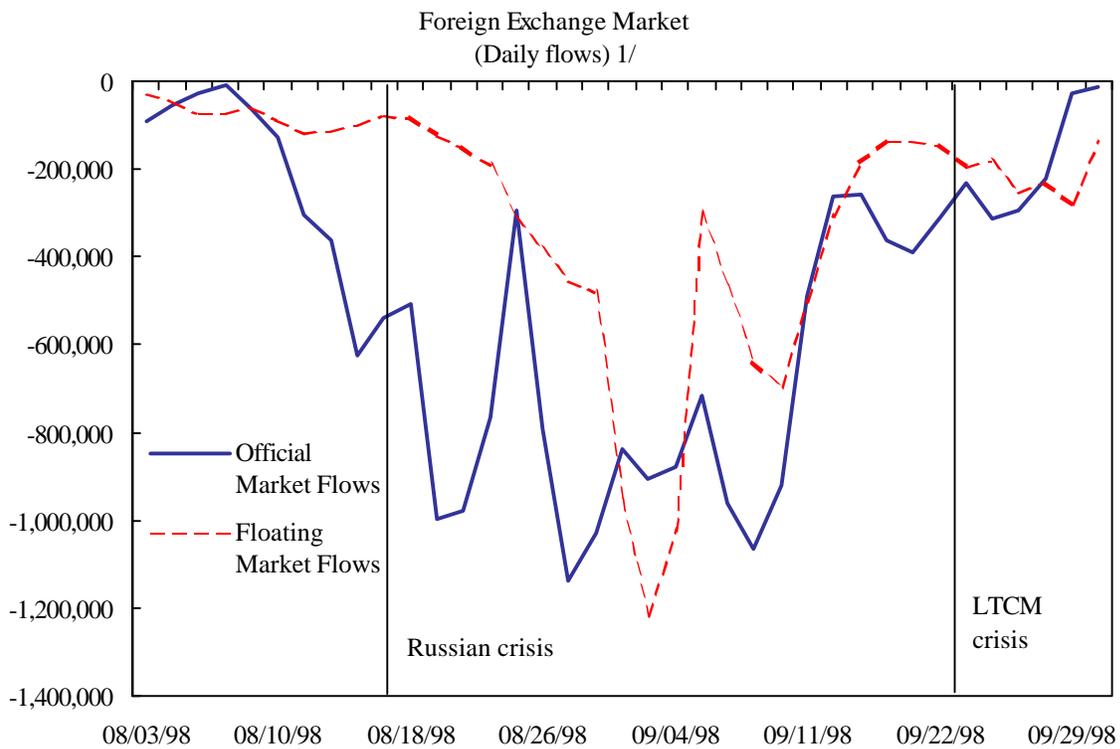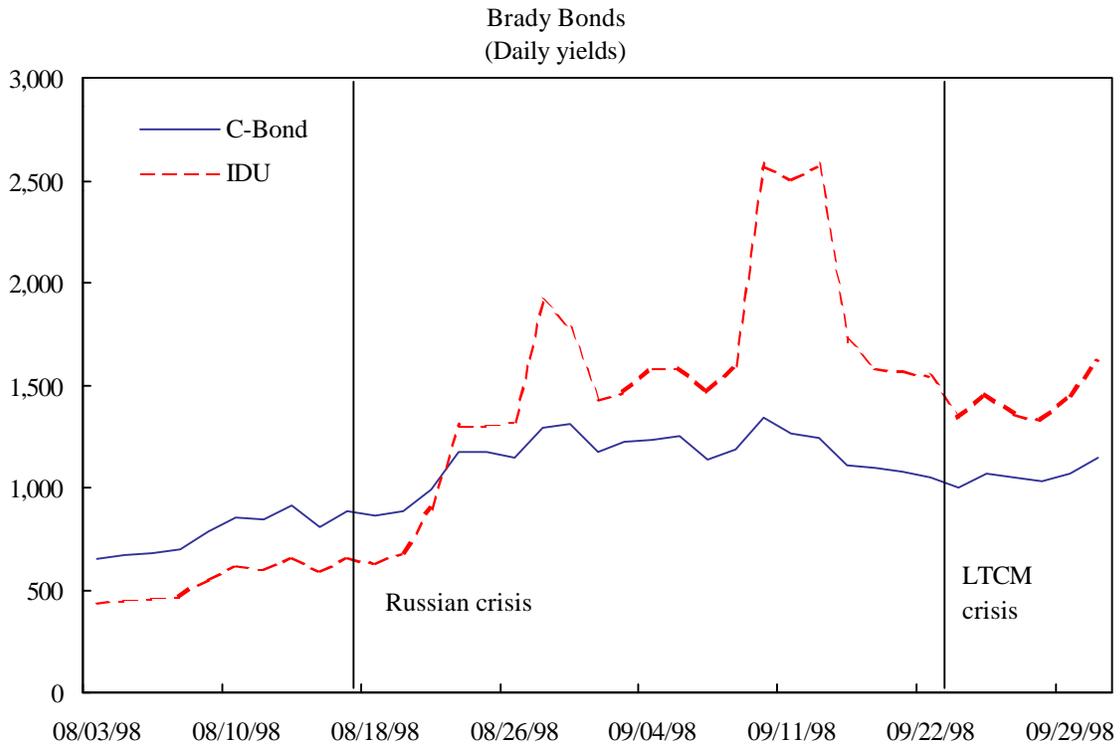
Source: Central Bank of Brazil; and Bloomberg.

1/ Negative sign denotes outflow.

Figure 3. Interest and Exchange Rates, January 1997-April 1999

Brazilian Interest Rate 1/
(In percent)

Exchange Rates
(National currency per U.S. dollar)
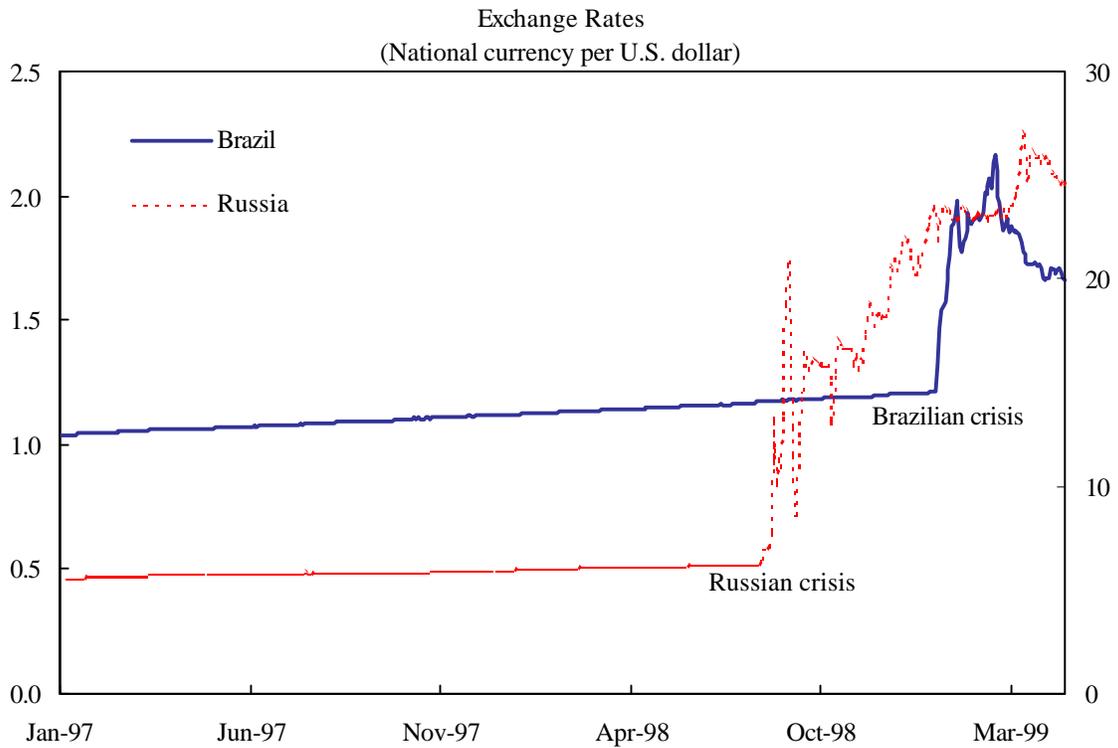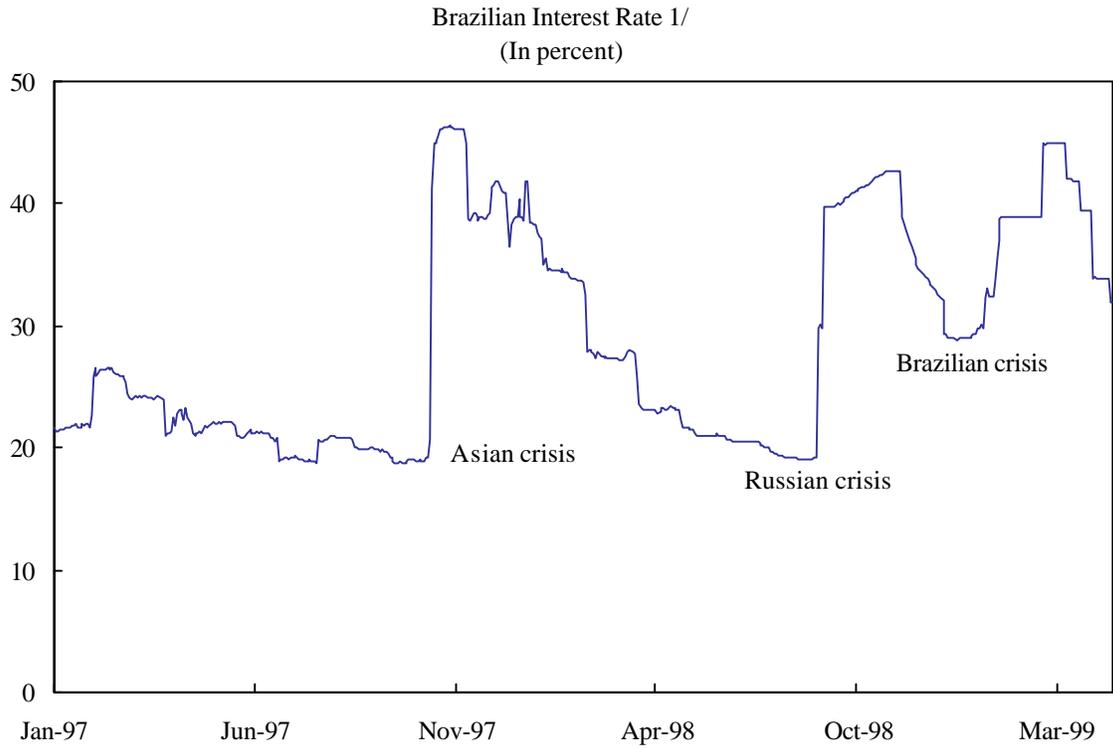
Source: Central Banks of Russia and Brazil.

1/ Rate used is SELIC rate, the Central Bank funds rate on overnight deposits.

C.   The effect of the Russian crisis on Brazilian capital Flows

Following a trend common to other emerging markets, private capital inflows to Brazil disappeared in the 1980s and increased dramatically after 1991. By 1993, the fall of international interest rates had eased the external debt burden, and it led to an agreement with creditor banks in 1994 with an exchange of instruments, covering over $50 billion in debt stocks and arrears.

At the end of 1994, Mexico's financial crisis led to an immediate cutback in capital flows to emerging markets. During the fourth quarter of 1994 and the first quarter of 1995, the net flow of capital to Brazil was insufficient to finance its current account, and the central bank lost reserves of about $9.8 billion. Private capital returned to Brazil soon, however, as a joint US-IMF bailout package of Mexico brought investors back to emerging markets. At the end of 1995 net capital flows were close to $30 billion, and in 1996 net inflows reached $33 billion. In the next two years net capital flows declined again, down to about $20 billion in 1998, owing to the impact of the Asian and Russian crisis, as well as the increasing perception that the Brazilian economy was in an unsustainable path.

The composition of flows during this period is interesting. Table 2 and Figure 4 show that the share of net direct investment increased steadily, surpassing $20 billion dollars in both 1998 and 1999. In contrast the crisis hit other components of flows very hard.

i.   Impact on capital flows

We devote this section to investigate the impact of the Russian crisis on monthly capital flows to Brazil. The ordinary least squares (OLS) regression model, controlling for heteroscedasticity and serial correlation, is:

$$nf = \frac{NF}{GDP} = \boldsymbol{b}_0 + \boldsymbol{b}_1(i - Ee) + \boldsymbol{b}_2 i^* + \mathrm{B}\,X + \boldsymbol{e},$$

where nf, i, i^*, Ee are the net capital flows as a percentage of GDP, the domestic interest rate, the US interest rate, and expected devaluation, respectively. X denotes a group of variables, including inflation, government spending, the real exchange rate, and a series of dummies for the Real Plan, the Tequila crisis, the Asian crisis, the Brazilian crisis, and the Russian crisis. The dummies take on a value of 1 during the month the crisis began. The results are summarized in Table 3 below.

As predicted by theory, the coefficient of the international interest rate is negative and significant. This result is consistent with evidence for Latin America in Calvo et al. (1993), and with the evidence for developing countries in Fernández-Arias and Montiel (1995). The result is robust across specifications and to using either returns on U.S. Treasury bills or

yields on 10-year Treasury bonds. The coefficient of the domestic interest rate adjusted for expected depreciation and the coefficients of other domestic factors do not help in explaining capital flows to Brazil. We interpret the results as evidence in favor of *push* effects as opposed to *pull* effects in explaining the movement in capital flows.

The dummies for the Tequila, Real plan and Asian crisis are strong and significant. However, the Russian crisis seems to have not affected significantly the flow of capital in a longer perspective. This is a bit surprising, but one should take into account the change in the composition of capital flows to Brazil in the mid and late nineties. Net foreign investment replaced other component of flows during this period, and that may have dampened the effect of the Russian crisis. In higher frequency (daily) data, we have observed a large withdrawal of capital during the Russian crisis. Therefore, from the point of view of lower frequencies and aggregated data (total flows), one cannot not observe the contagion effects from the Russian crisis to Brazil. Also, the regression results could be interpreted as indicative of the fact that the Russian crisis did not have an impact on the medium and long term flows to Brazil.

Table 2. Brazil: Capital Flows, 1991-99

(In millions of U.S. dollars)

	1991	1992	1993	1994	1995	1996	1997	1998	1999 1/
Net direct investment	-408	1,268	-481	852	2,376	9,519	15,364	22,988	25,946
Foreign direct investment	505	1,156	397	117	5,475	10,349	17,086	26,134	27,109
Reinvestment	365	175	100	83	384	531	151	124	…
Net domestic investment	-913	112	-878	-1,065	-1,560	77	-1,569	-3,212	-1,163
Equity securities	578	1,704	6,651	7,280	2,294	6,040	5,300	-1,861	1,529
Debt securities	2,368	5,761	5,866	3,713	3,113	12,727	19,771	28,968	-7,982
Short-term capital and others	-7,406	-2,844	-4,432	-3,824	15,523	4,857	-15,517	-30,032	-1,943
Total	-4,868	5,889	7,604	8,020	29,306	33,142	24,918	20,063	…

Source: Central Bank of Brazil; and authors' estimates.

1/ 1999 data are for January through November.

Figure 4. Brazil: Composition of Capital Flows, June 1988-November 1999

(Six-month moving averages)
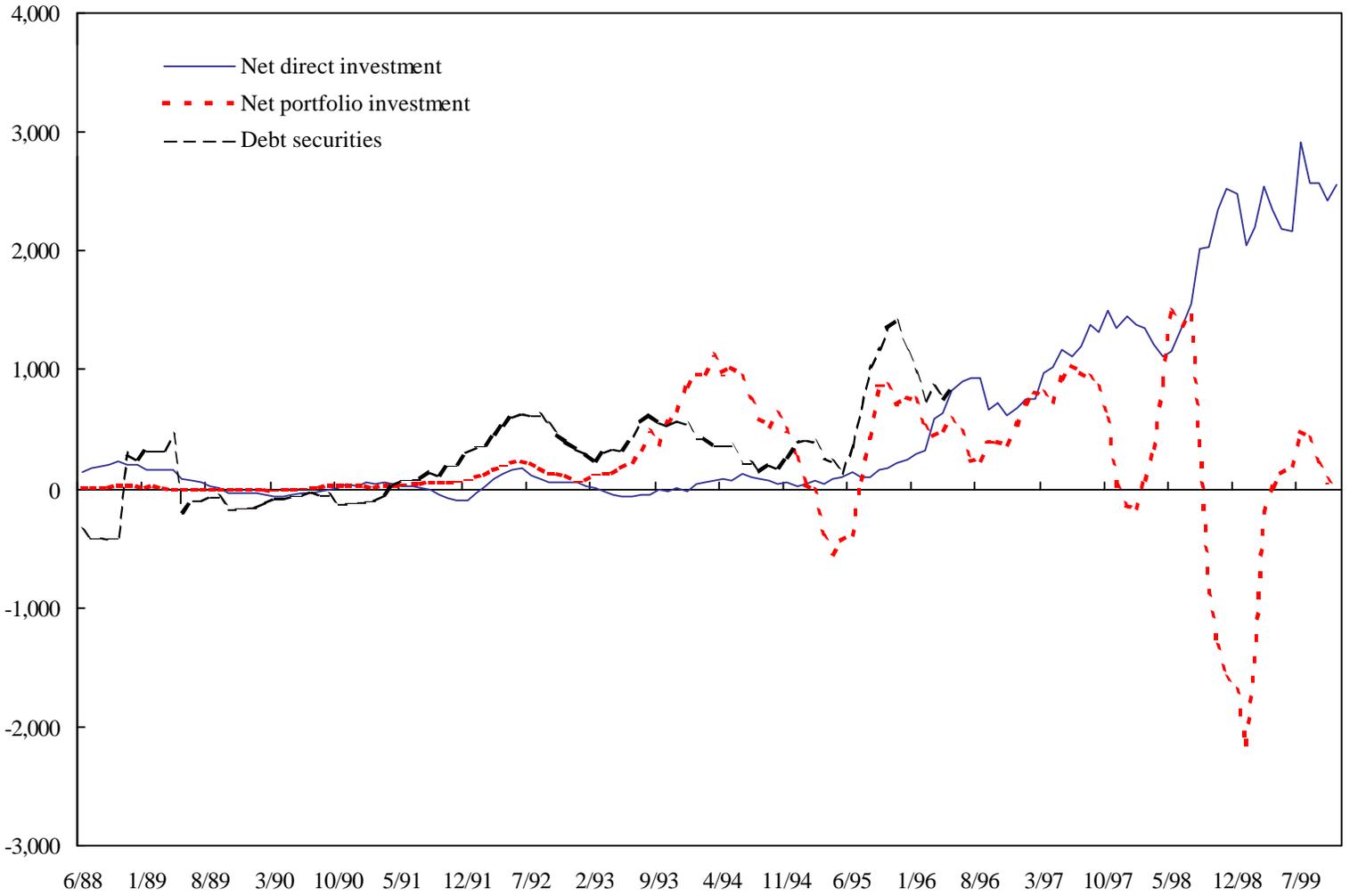
Source: Central Bank of Brazil.

Table 3. Regression Results: Impact of the Russian Crisis on Capital Flows to Brazil
(Dependent variable: Ratio of monthly total net private capital flows to GDP)

	Sample: January 1988-November 1999			Sample: January 1995-November 1999	
Constant	4.78	4.95	5.28	24.83	42.75
	5.05	5.14	2.69	1.20	2.23
i*	-0.64	-0.68	-0.79	-3.87	-7.04
	-4.60	-4.68	-3.13	-0.99	-1.86
i - Ee	-0.01	-0.13	0.02	-0.62	-0.42
	-0.62	-0.64	0.50	-3.19	-0.94
Tequila dummy	-5.65	-5.96	-6.07		
	-5.60	-5.43	-5.33		
Real plan dummy	2.47	2.78	2.49		
	2.98	2.99	2.46		
Asian dummy	2.73	2.41	2.42	1.77	1.11
	2.99	2.42	2.42	1.25	0.87
Russian dummy	-	-4.60	-4.86	-6.50	-8.00
		-1.63	-1.54	-1.29	-1.67
Brazilian dummy	-	-0.56	-0.09	-2.83	3.03
		-0.47	-0.06	-1.07	0.40
Inflation rate	-	-	0.01	-	-0.27
			0.28		-0.36
Ratio of government spending to GDP	-	-	2.38	-	-26.38
			0.24		-1.05
Real exchange rate (deviation from equilibrium rate)	-	-	-2.48	-	-26.29
			-0.55		-0.87
Adjusted R^2	0.24	0.26	0.25	0.05	0.09

 Source: Central Bank of Brazil; and authors' estimates.

ii.   Impact on short term exposure

Subsequent to the crisis in Russia, and leading up to the real's devaluation, foreign investors reduced their exposure to Brazil as maturing obligations came due. The Central Bank of Brazil's survey data, which follows the maturing short term external liabilities of its banking system in a weekly basis, provides interesting insight regarding this issue.[3]

Table 4 shows the cumulative reduction in short term exposure to Brazilian banks by nationality in the last quarter of 1999. Over the sample period, out of the total US$6.6 billion that was maturing, about US$4 billion was rolled over, amounting to a rollover rate of around 62 percent. U.S. banks reduced their exposure by US$931 million, with a rollover rate of 60 percent. Within the US, almost one-half of the reduction came from two banks, and ten banks accounted for 84 percent of the total decline. Many regional banks were found to have reduced their exposure.

The rollover rate for US banks was well below the rollover rates of Germany (79 percent) and the UK (77 percent), although it was roughly in line with Japan (58 percent), France (54 percent) and Italy (60 percent). This is interesting because it bears on our fundamental question regarding the contagion from Russia to Brazil. As table 4 shows, German banks, which had huge exposure to Russia and were consequently badly affected by the Russian crisis, had a rollover rate far above the group average. Thus the hypothesis that liquidity needs and withdrawals were one of channels of contagion does not find support from the data. The available evidence does not reflect a compensatory liquidation of assets.[4]

The data also allows us to follow the timing of the reduction of exposure, although with a lag given that the first data is from the third week of October. Figure 5 shows the net outflows per week and the rollover rate over time. The weekly changes in exposure have been volatile, with a particularly sharp deterioration in October and over the final two weeks of the year, which was principally due to end-year window dressing. The high rollover weeks happen in April, 1999 after the Brazilian agreement with international banks to maintain short term credit lines. For the 11-week monitoring period ending January 1, 1999, the aggregate rollover rate was 72 percent. The weekly observations, however, have been volatile, ranging from 50 percent to 90 percent. It is interesting also to note that the

---

[3] The short term obligations include interbank and credit lines. The survey based monitoring system was introduced on October 1998, after the Russian crisis and during the negotiations with the IMF.

[4] It is noteworthy that German banks received a large number of guarantees on their Russian loans from the state-supported export-guarantee agency Hermes, which may have lessened their losses compared to other banks. Besides, they had set aside higher provisions for bad debts than other countries' banks.

international banks did not increase their exposure to the levels seen before the Russian crisis. This was in part due to lack of demand for short term borrowing by Brazilian banks after the floating of the exchange rate and the associated higher exchange rate risk.

Table 4. Brazil: Changes in Exposure of Short-term Loans, October 1-Decmber 31, 1998 1/
(In millions of U.S. dollars)

	Amount Maturing	Amount Rolled Over	Rollover Rate
United States	2,352	1,421	0.60
Canada	168	74	0.44
France	947	516	0.54
Germany	1,060	835	0.79
Italy	215	129	0.60
Japan	715	416	0.58
Netherlands	222	69	0.31
Portugal	97	90	0.93
Spain	350	145	0.41
UK	505	389	0.77
Total	6,630	4,082	0.62

Source: Central Bank of Brazil; and authors' estimates.

1/ Includes interbank loans and trade credits.

Figure 5. Brazil: Short-term Capital Flow and Rollover Rates, October 1998-July 1999

Weekly Short-term Capital Flow
(In millions of U.S. dollars)

Brazilian Crisis and Short-term Rollover Rates
(Cumulative rates)
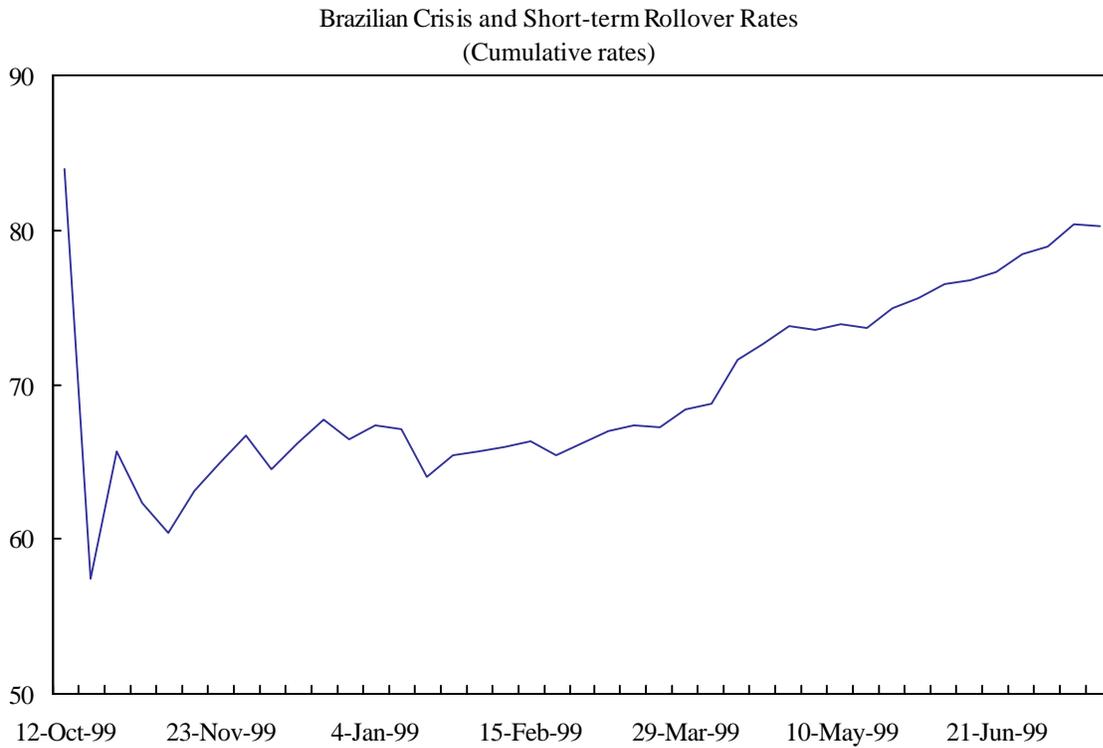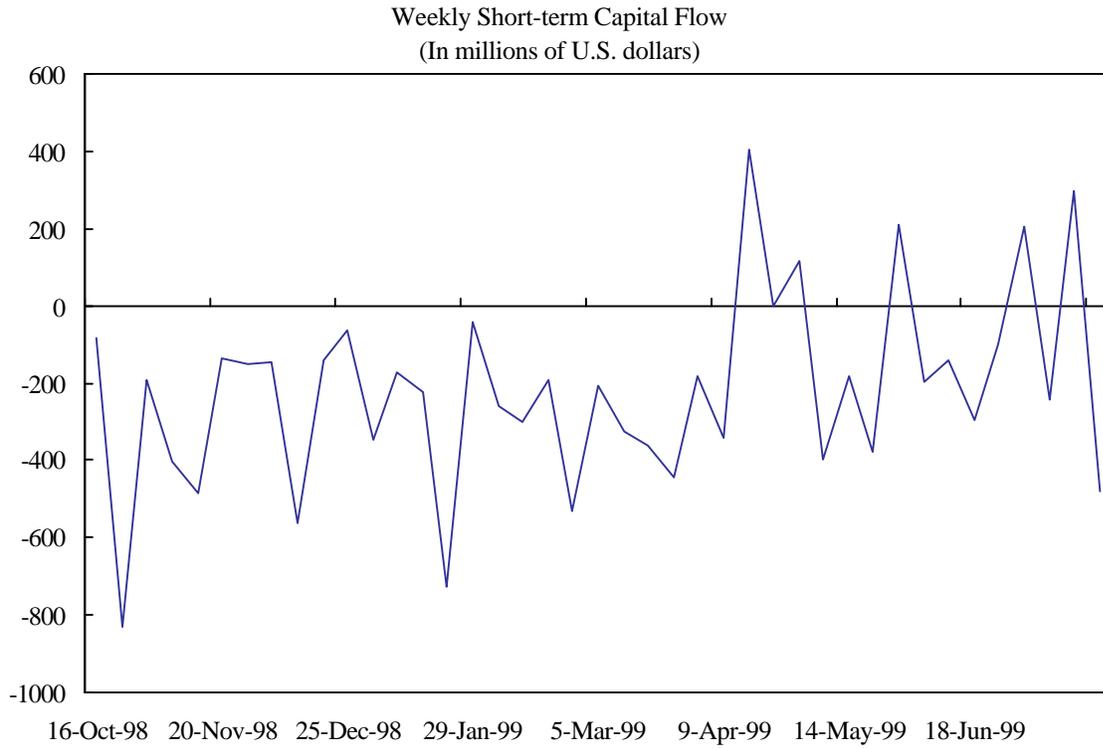
Source: Central Bank of Brazil; and authors' estimates.

iii. BIS data and overall bank exposure

The weekly monitoring system by the central bank of Brazil has the advantage of a higher frequency but the coverage is not universal, as only short term assets are included. In contrast, the data from the Bank for International Settlements (BIS), published twice a year, has a broader coverage. Table 5 and Figure 6 show the overall exposure of reporting banks on Brazil and other emerging markets. The exposure on Brazil decreased by around $10 billion dollars from the first half of 1998 to the first half of 1999, while the exposure in Russia decreased by almost $15 billion dollars in the same period.

It is interesting to note the similar path for the banks exposure to Russia and Brazil, in contrast to the rest of Latin America, in particular Mexico and Argentina. The reduction of the exposure to Asia diminished about a year earlier. The different paths for the exposure on Brazil and the rest of Latin America provides support to the fact that the contagion from the Russian crisis was not generalized, as it would be if driven only by liquidity needs.

Table 5. Commercial Banks' Exposure to Selected Countries, 1997H1-1999H1 1/
(In millions of U.S. dollars)

	Brazil	Mexico	Russia	Argentina
1997H1	71,862	62,161	69,081	44,844
1997H2	76,292	61,794	72,173	60,413
1998H1	84,585	62,892	75,853	60,222
1998H2	73,313	64,962	58,594	61,517
1999H1	62,310	63,776	55,424	66,683

Source: Bank for International Settlements.

1/ H refers to half-yearly data.

Figure 6. Bank Holdings in Emerging Markets, 1995-1999
(Index: 1994H2=100) 1/
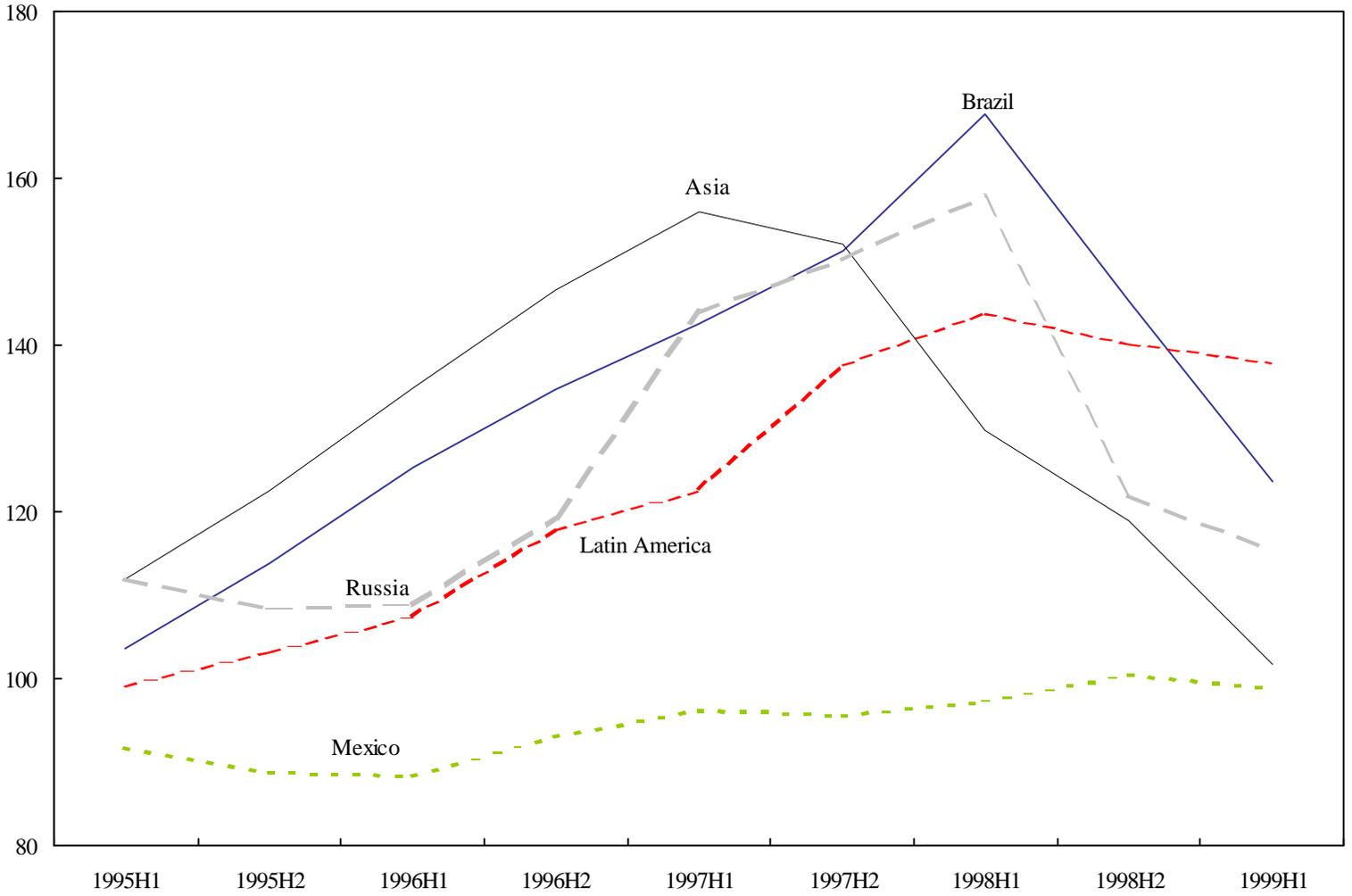
Source: Bank for International Settlements.

1/ H refers to half-yearly data.

III.   EMPIRICAL TESTS OF CONTAGION

A. Methodology

In this exercise, we primarily focus on the stock indices and sovereign spreads. Analyzing the currency market is not very useful as for most of the sample period, both the Brazilian real and the Russian ruble were fixed to the dollar. The currencies move about relatively freely only after January 1999 (when the Real peg unraveled), but that period leaves out many important phases of the crisis. Instead of directly looking at the exchange rate, we devote a part of our analysis to the data from financial flows, which in turn is affected by associated exchange rate volatility.

In order to understand the transmission of shocks from Russia to Brazil, we carry out a series of tests. We begin by looking at rolling correlations (at three month interval) between the relevant variables. We also use reduced form VARs to examine the direction of shocks between Russia and Brazil.

We then define crisis and tranquil periods, and test for significant changes in correlations between the two periods. We apply the Forbes and Rigobon (1999) methodology to adjust the crisis period correlations for sudden increase in variance (see Appendix). The motivation for this approach is to control for the correlation bias associated with higher variances, as in the standard correlation formula, higher variances lead to higher correlations. Once the adjustment is performed, crisis period correlations can be tested for significant increases without the potential of this bias. However, we use the Forbes and Rigobon test with caution, as we are not sure a study of contagion ought to control for the increased variances, as volatility is an integral part of any crisis scenario. It could very well be that the factors behind the increased variances (thin markets, panic, institutional failure, etc.) are precisely what make up contagion, and controlling for these factors make test for contagion moot.

B. Dummy variables

One can define contagion as co-movements in financial variables in excess of those that can be explained by co-movements of fundamentals. Under this definition, in order to identify contagion, it is essential to distinguish between fundamentals and non-fundamentals-driven co-movements. Empirically, if, after controlling for fundamentals, one finds significant co-movement among the markets of two countries, then the remaining unexplained correlation may be attributed to contagion (for example, panic or investor sentiment shift).

There are significant empirical difficulties to implement this methodology of identifying contagion. Given that most fundamentals are measured infrequently, at least in comparison to the frequency available for financial data, one has to be sure that there is comprehensive and reliable data available that represents movements in fundamentals. In

general, there are no high frequency variables (e.g. daily data) that can approximate fundamentals in each country. In the absence of such data, one approach is to create a set of daily variables constructed from news reported by the press that could proxy for movements in fundamentals. This approach follows Ganapolsky and Schmukler (1998) and Kaminsky and Schmukler (1998), who attempt to estimate the impact of various news events on market movements. These papers map daily news of a country into a set of dummy variables in order to quantify the impact of policy announcements and other news on financial markets. We followed this literature, as well as our previous work (Baig and Goldfajn, 1999) and created two series of dummy variables—good and bad news—for each country.

The mapping of fundamentals to news and then to a couple of dummy variables involves an inevitable degree of subjectivity. However, in order to ensure a rigorous and replicable procedure, we provide in the appendix a set of guidelines that we followed.

Although parts of these "news" were in some degree expected by the market and, therefore, already factored in the financial variable prices, there always remains some uncertainty that is realized the day the announcement effectively occurs. For example, days when bailout packages are announced or central bank statements are released are well known in advance, but the market nevertheless reacts to them, revealing that there was some degree of uncertainty whether these announcements were to occur. We therefore included "news" that were partially anticipated.

In the regression exercise we first regress the financial variables of the countries on their own news and other selected fundamentals. The idea is that own news is a proxy for changes in fundamentals, whereas changes in the fortune of another country is a potential source of contagion. Second, we regress for each country its financial variable against dummies of both countries on the right hand side to evaluate the impact of cross-border news.

We begin our investigation by trying to establish the correct sample period to study. We want to be able to define a tranquil and crisis episode in order to compare results from the two periods and analyze the factors behind the movements. Given the numerous shocks that financial markets have faced recently, isolating a period of relative tranquility is somewhat difficult. Simply choosing a period before the August 98 Russian default is not sufficient, as the emerging markets were hit by the Asian crisis in late 1997 and 1998. As Figures 7 and 8 show, the markets in both the countries in discussion were affected by the Asian crisis as spreads shot up. Thus the data from that period onwards is likely to contain some noise. With this in mind, we choose January 1, 1997 to May 30, 1997 as our tranquil period. For the crisis period, we use data from January 1, 1998 onwards for correlation and VAR analysis. For the regressions, we use dummy variables that are defined from a month prior to the Russian default; therefore our sample begins from July 1, 1998.

Figure 7. Brazil and Russia: Stock Market Indices, January 1, 1997-June 30, 1999
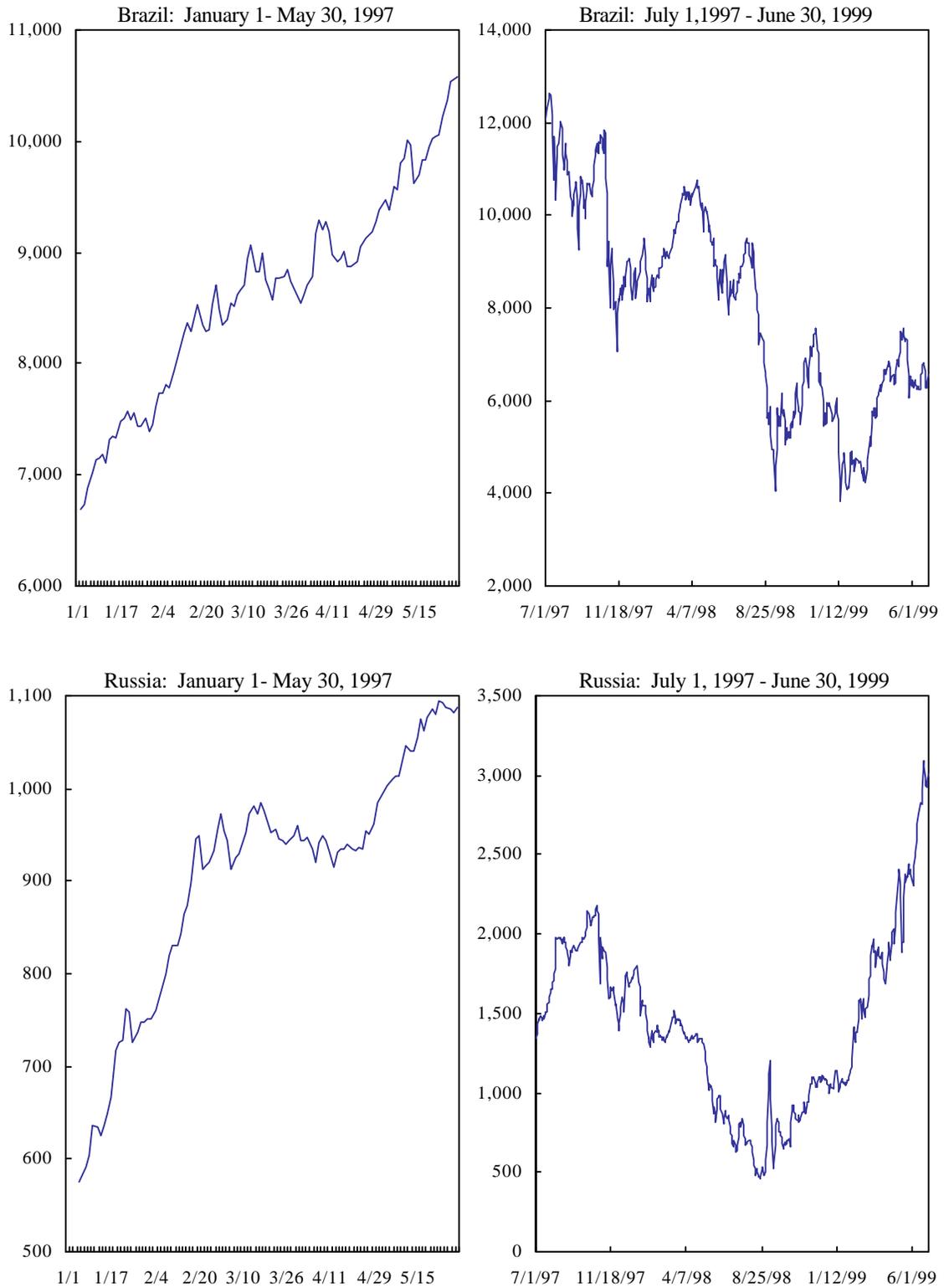

Source: Bloomberg.

Figure 8. Brazil and Russia: Sovereign Spreads, January 1, 1997-December 31, 1998
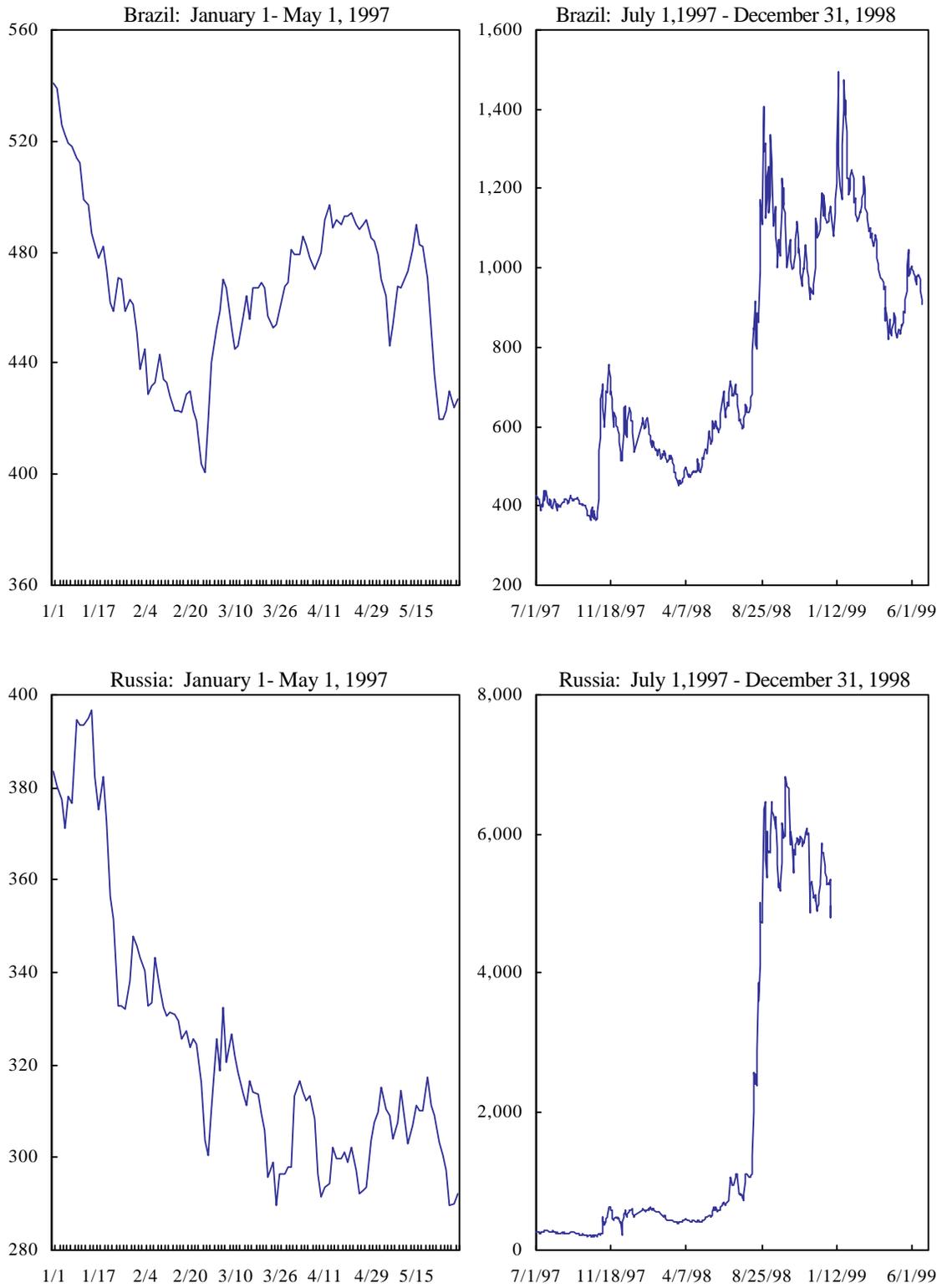
Source: Bloomberg.

C. Correlation and VAR results

i.   Stock market

The first half of 1997 can be termed as a very favorable time for both the Brazilian and Russian equity markets, as they returned, in dollar terms, 58 and 88 percent respectively during the defined tranquil period. There is little evidence of interaction between the two markets though. Correlation of the first log difference between the two markets was –0.11 during this period. Using two lags in a reduced form VAR, we find impulse responses (see Figure 9) that reveal some evidence of the Russian equity market being affected by shocks in the Brazilian market.

As the Asian crisis unfolded in the fall of 1997, the Brazilian stock market showed some signs of nervousness, but the Russian market seemed undisturbed. Rolling correlations, using three month windows, between September and December of 1997 show somewhat higher, yet fairly stable, correlation between the two markets.

We find the correlations increase substantially by the first quarter of 1998, as Brazil's internal and external difficulties became more visible and Russia began to show signs of nervousness (see Table 6). As financial difficulties in Russian became acute, correlations hit 0.51 in the April-June, 1998 window. We find correlations to go down drastically once the Russian devaluation took place in August, but that is primarily a reflection of the sharp decrease in the dollar value of the Russian stock index due to the depreciation of the ruble. More importantly, correlations go up substantially again from October onwards, when the crisis in Brazil worsens. It must be noted that the stock market correlations are not very high at any point in the sample, with the highest magnitude of 0.51 is seen in the April-June, 1998 window.

In the impulse response functions (see Figure 9) from reduced form VARs, we find significant impulse responses in Brazil from one standard deviation innovation in Russia. This is valid only in the crisis period and not in the tranquil times, confirming our suspicion of contagion from Russia to Brazil.

Figure 9. Impulse Response Functions (From Reduced-form VARs)
(Response of stock market in U.S. dollars to one S.D. innovation;)

Tranquil Period (January 1,1997 - May 30,1997)

Response of Brazil to Russia
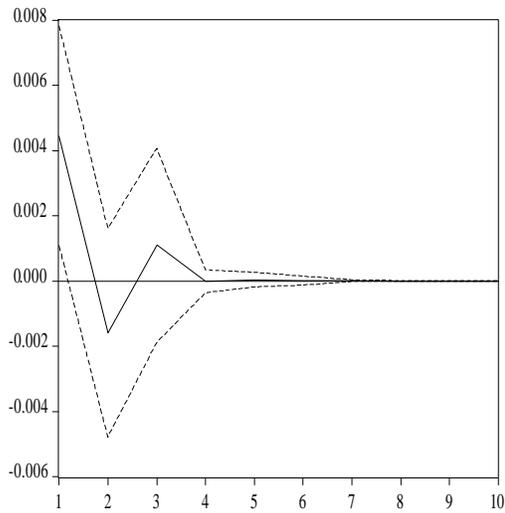
Response of Russia to Brazil
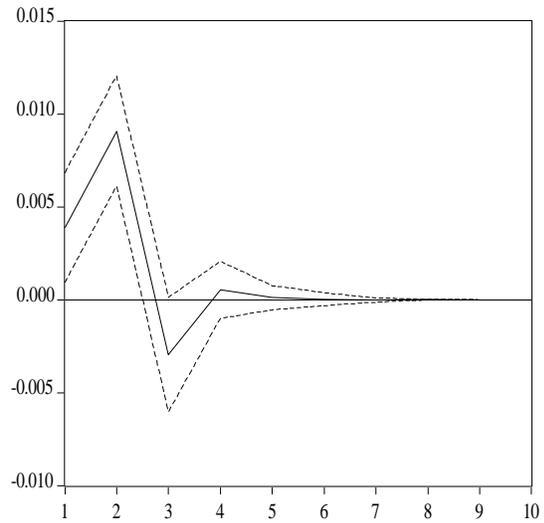
Crisis Period (January 1,1998 - June 30,1999)

Response of Brazil to Russia
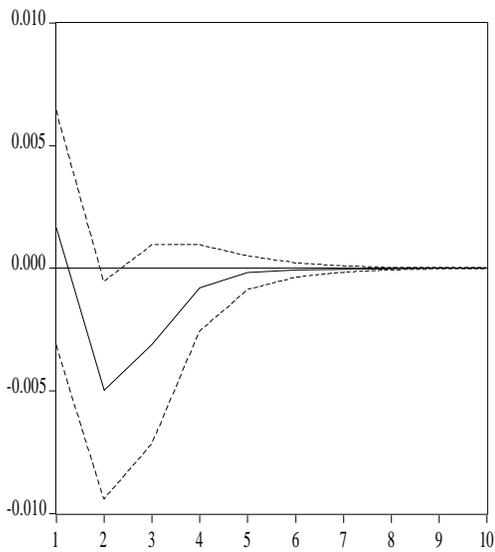
Response of Russia to Brazil
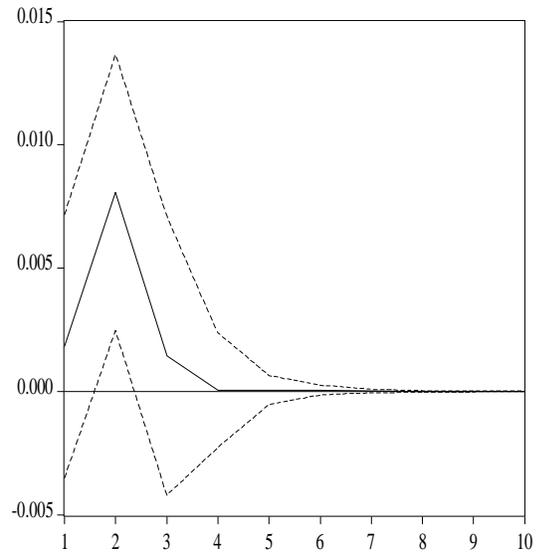
Source: Authors' estimates.

Table 6. Brazil and Russia: Stock Market Correlations, January 1997-June 1999 1/
(Market indices in U.S. dollars; first log differences)

		Number of observations	Unadjusted correlation	Adjusted correlation	T-stat
Tranquil Period					
	01/01/1997 - 05/30/1997	83	-0.11		
Crisis Period					
Full Sample	09/01/1997 - 12/31/1998	300	0.04	0.01	0.47
Three-month windows	09/01/1997 - 11/28/1997	63	0.22	0.11**	2.27
	10/01/1997 - 12/31/1997	58	0.21	0.09**	1.88
	10/31/1997 - 01/30/1998	53	0.34	0.19**	3.72
	12/01/1997 - 02/27/1998	49	0.27	0.16**	2.82
	01/01/1998 - 03/31/1998	52	0.18	0.11**	2.14
	01/30/1998 - 04/30/1998	53	0.31	0.29**	5.73
	02/27/1998 - 05/29/1998	54	0.39	0.27**	5.24
	04/01/1998 - 06/30/1998	52	0.51	0.28**	5.30
	05/01/1998 - 07/31/1998	56	0.44	0.18**	3.62
	06/01/1998 - 08/31/1998	61	0.36	0.14**	2.90
	07/01/1998 - 09/30/1998	62	-0.17	-0.04	-0.75
	07/31/1998 - 10/30/1998	62	-0.15	-0.03	-0.66
	09/01/1998 - 11/30/1998	57	-0.20	-0.04	-0.83
	10/01/1998 - 12/31/1998	54	0.13	0.06	1.12
	10/30/1998 - 01/29/1999	49	0.26	0.16**	2.90
	12/01/1998 - 02/26/1999	46	0.22	0.13**	2.23
	01/01/1999 - 03/31/1999	50	0.27	0.14**	2.60
	02/01/1999 - 04/30/1999	51	0.20	0.10**	1.82
	03/01/1999 - 05/31/1999	52	0.17	0.07	1.21
	04/01/1999 - 06/30/1999	48	0.13	0.05	0.93

Source: Bloomberg; authors' estimates.

1/ Placement of ** and * denotes significance at 5% and 10% levels respectively.

ii.   Sovereign spreads

The tranquil period sovereign spreads correlations are substantially larger than what we saw in the stock market case. Using 106 observations from January – May, 1997, we find the correlation to be 0.35. The spreads of both the bonds in discussion shot up even further in the crisis period (see Figure 8). The correlation of the spreads also jumped (see Table 7), and remained at very high levels till late 1998.

The adjusted correlations for the spreads show significantly higher correlation during the crisis period sub-samples when compared to the tranquil period (see Table 7). All but two sub-samples in the crisis period had significantly higher adjusted correlations. This confirms our findings from previous work (Baig and Goldfajn, 1998) that the correlations in the Brady markets are very high and increases significantly (even after the adjustment) during the crisis. This gives support to the fact that if there was a contagion from Russia to Brazil, the most likely place of the transmission was the off-shore Brady markets.

The impulse responses (see Figure 10) show mutually reinforcing responses during the crisis period.

iii.   Financial flows

The financial flows variables allow us to look deeper into the market dynamics of Brazil, and see how the two markets, one dominated by domestic players and the other by foreigners, behaved. Financial flows are the balance of the foreign exchange transactions in the financial markets. Ultimately the government would have to balance the market in order to keep the exchange rate within the crawling peg band. However, the changes in reserves do not necessarily track down exactly the financial exchange flows because some of the transactions are settled with a lag period (30-days and so).

We find a correlation of –0.16 between the two markets during the tranquil period (see Table 8). VARs do not provide evidence any shocks transmitting from one market to the other.

We find that the directly after the onset of the Asian crisis, correlation between these two markets jumped (up to 0.74 in September-December, 1997). The rolling correlation show a great deal of volatility through 1998 as the correlations become negative and then positive. The impulse response function (see Figure 11) from the crisis period also show that the reaction of the official flows to innovations in the floating market flows is statistically significant.

This is significant as the implication is that the local players precede foreign investors in withdrawing capital from the crisis-affected country (as also found in Frankel and Schmukler, 1996). This is consistent with the findings obtained in the previous section, where we saw that withdrawals in the floating market were present in both the Asian and

Figure 10. Impulse Response Functions (From Reduced-form VARs)
(Response of sovereign spreads to one S.D. innovation)

Tranquil Period (January 1,1997 - May 30,1997)

Response of Brazil to Russia

Response of Russia to Brazil

Crisis Period (January 1,1998 - December 31, 1998)

Response of Brazil to Russia

Response of Russia to Brazil
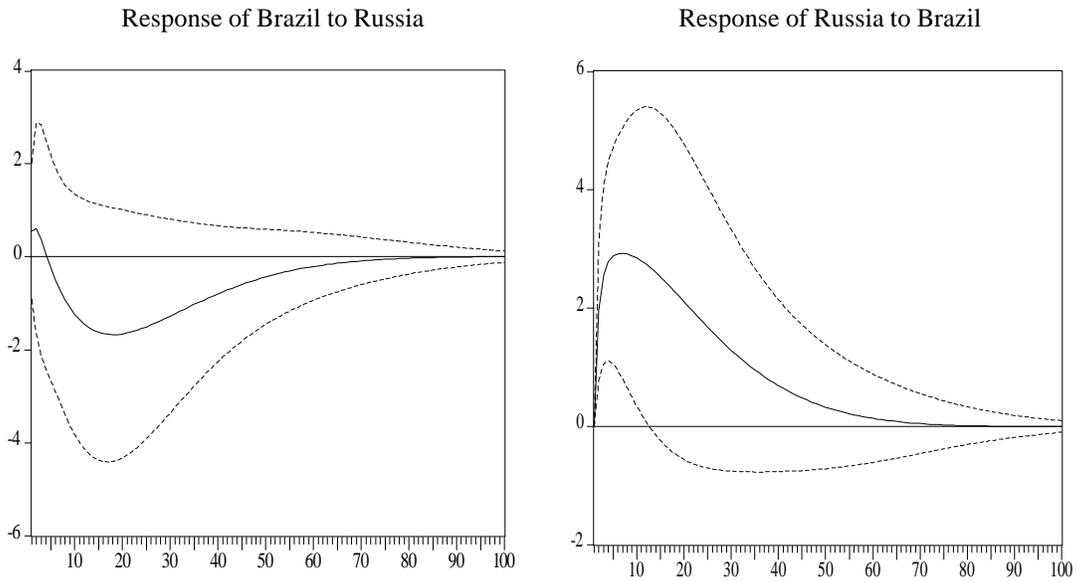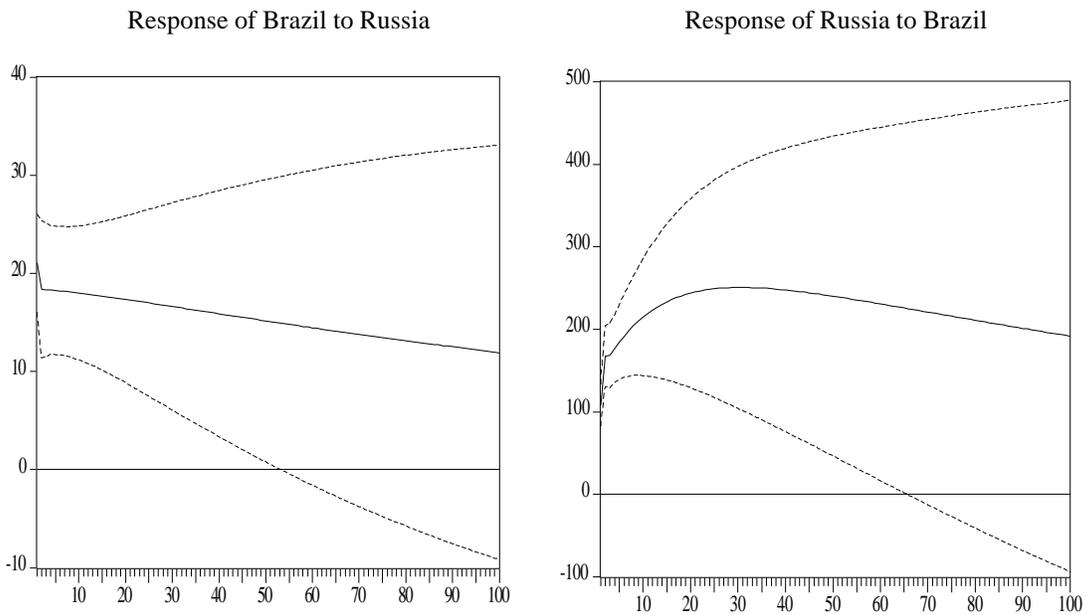
Source: Authors' estimates.

Table 7. Brazil and Russia: Sovereign Spread Correlations, January 1997-December 1998 1/

		Number of observations	Unadjusted correlation	Adjusted correlation	T-stat
Tranquil Period					
	1/01/1997 5/30/1997	106	0.35		
Crisis Period					
Full Sample	09/01/1997 12/31/1998	335	0.94	0.32	-1.31
Three-month windows	09/01/1997 11/28/1997	65	0.87	0.97**	39.55
	10/01/1997 12/31/1997	66	0.82	0.94**	33.00
	10/31/1997 01/30/1998	58	0.41	0.85**	19.11
	12/01/1997 02/27/1998	57	0.51	0.93**	27.21
	01/01/1998 03/31/1998	55	0.87	0.99**	46.34
	01/30/1998 04/30/1998	62	0.86	0.99**	54.63
	02/27/1998 05/29/1998	62	0.89	0.99**	63.42
	04/01/1998 06/30/1998	62	0.91	0.97**	40.67
	05/01/1998 07/31/1998	65	0.79	0.86**	21.80
	06/01/1998 08/31/1998	66	0.98	0.67**	10.73
	07/01/1998 09/30/1998	65	0.97	0.46	2.98
	07/31/1998 10/30/1998	64	0.85	0.27	-2.17
	09/01/1998 11/30/1998	63	0.29	0.50	4.23
	10/01/1998 12/31/1998	65	-0.03	-0.02	-9.04

Source: Bloomberg; authors' estimates.

1/ Placement of ** and * denotes significance at 5% and 10% levels respectively.

Table 8. Brazil and Russia: Financial Flows Correlations, January 1997-99 1/

		Number of observations	Unadjusted correlation	Adjusted correlation	T-stat
Tranquil Period					
	1/01/1997 5/30/1997	100	-0.16		
Crisis Period					
Full Sample	09/01/1997 12/31/1998	336	0.31	0.08**	2.90
Three-month windows	09/01/1997 11/28/1997	65	0.74	0.19**	4.15
	10/01/1997 12/31/1997	65	0.74	0.19**	4.15
	10/31/1997 01/30/1998	64	0.1	0.05	1.01
	12/01/1997 02/27/1998	61	-0.22	-0.22	-4.58
	01/01/1998 03/31/1998	61	-0.07	-0.07	-1.41
	01/30/1998 04/30/1998	60	-0.32	-0.15	-3.22
	02/27/1998 05/29/1998	62	-0.19	-0.08	-1.67
	04/01/1998 06/30/1998	60	-0.4	-0.18**	-3.79
	05/01/1998 07/31/1998	64	-0.1	-0.06	-1.31
	06/01/1998 08/31/1998	65	0.28	0.17**	3.65
	07/01/1998 09/30/1998	65	0.38	0.08	1.71
	07/31/1998 10/30/1998	64	0.21	0.04	0.82
	09/01/1998 11/30/1998	62	0.27	0.05	1.04
	10/01/1998 12/31/1998	63	-0.22	-0.06	-1.29
	10/30/1998 01/29/1999	62	0.64	0.44**	10.00
	12/01/1998 01/29/1999	41	0.71	0.46**	7.76
	01/01/1999 01/29/1999	19	0.83	0.53**	4.40

Source: Central Bank of Brazil; and authors' estimates.

1/ Placement of ** and * denotes significance at 5% and 10% levels respectively.

Figure 11. Impulse Response Functions (From Reduced-form VARs)
(Response of financial flows to one S.D. innovation)

Tranquil Period (January 1,1997 - May 30,1997)

Response of Floating to Official Flows

Response of Official to Floating Flows

Crisis Period (January 1,1998 - December 31, 1998)

Response of Floating to Official Flows

Response of Official to Floating Flows
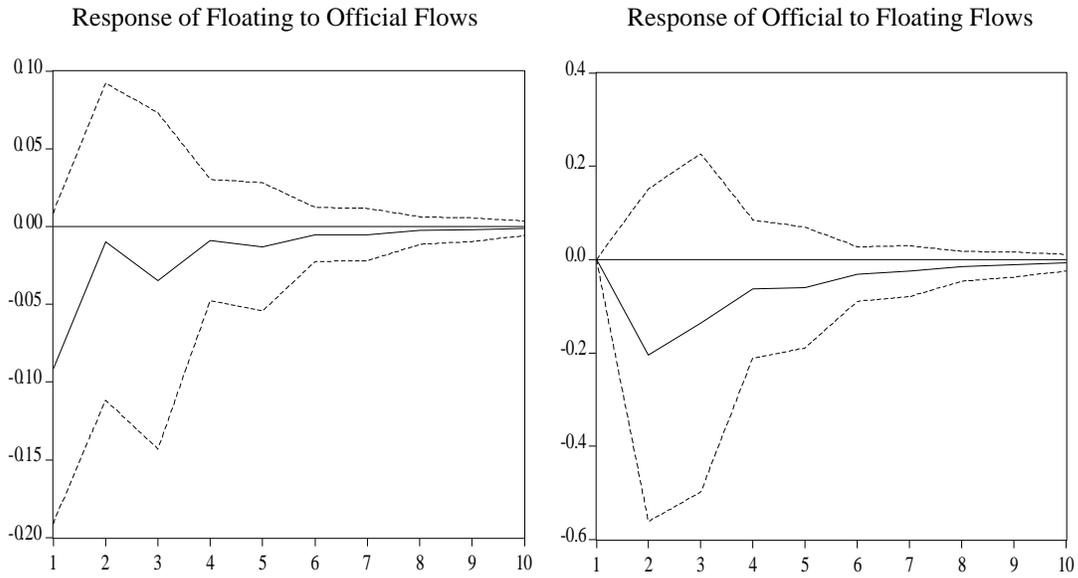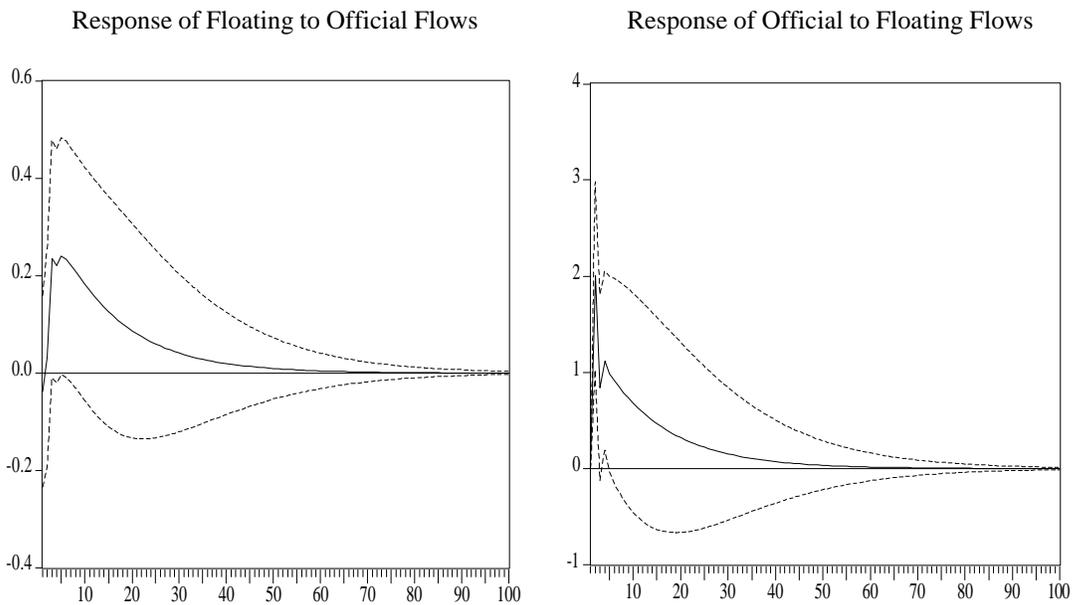
Source: Authors' estimates.

Russian crisis but were followed by withdrawals in the official market only in the latter. This induced the larger effect that eventually led to the Brazilian crisis.

The adjusted correlations (see Table 8) show that occasional sub-sample periods when the crisis period correlations were higher than the tranquil period. The correlations also show that subsequent to the Russian default there was surge of co-movement among these markets.

D. Regression results

In this analysis, we only focus on the crisis period dynamics around the onset of the Russian crisis. We were unable to carry out a cohesive filtering of the data prior to this period, due to confusion regarding what constitutes good or bad news outside the context of the devaluation of currencies and debt defaults in discussion.

i. Stock market

We begin by regressing the first log difference of the Russian and the Brazilian stock market indices against their own good and bad news dummies, as well selected fundamentals (US interest rate, Deutsche mark-dollar exchange rate, and the changes in the S&P stock index in the US). For Brazil (see Table 9), we find that only changes in the US stock market has a significant impact, with the right sign. Bad news from Russia also seem to have an adverse impact, but only at a marginal 11 percent level of significance. For Russia, only bad news from own-country has a significant and adverse impact on the stock market performance.

We then extend our analysis by including cross-country news dummies and fundamentals on the right hand side of the regressions. The results are somewhat more promising here. In the Brazil regression, bad news stemming from Brazil have a significant and negative impact, thus providing further evidence of cross-border transmission of shocks. The US stock market movements also have the right sign and statistical significance. Throwing in the additional variable does not add much to the Russia regression, as the sole variable of significance remain the Russian news dummy.

ii. Sovereign spreads

In the regressions with own-country news and other fundamentals (see Table 10), the only variable that is statistically significant for the spreads in Brazil and Russia is the US interest rate. In both regressions the US interest rate has a negative coefficient, which means that increases in US interest rate leads to lowering of spreads in both the countries in discussion.

For the extended regressions, in addition to the cross-country news dummies, we add the stock market variables of both countries. In the regression for Brazil with the cross-country dummies, bad news out of Russia has a significant and adverse impact on Brazilian

spreads. In the Russia regression, own-country good news is significant, with the expected sign. In both regressions, US interest rate remains significant and negative.

iii. Financial flows

During our correlation and causality work we found that that the Brazilian floating flows had a significant impact on the official flows. It is important to establish what caused the movement in the floating flows, as that will shed light on the reaction pattern of the local market participant s in Brazil. Regressing the floating flows on the Brazilian dummies and selected fundamentals, we find mark-dollar exchange rate and the bad news dummy from Brazil to be significant (see Table 11). The positive coefficient with the exchange rate imply that appreciation of the dollar leads to increase in floating flows, whereas the negative news coefficient implies that bad news leads to decrease in the flows.

Table 9. Brazil and Russia: Stock Market Regression Results 1/

(Sample: July 1, 1998-April 30, 1999; market indices in U.S. dollars; first log difference)

Dependent Variable:	Brazilian Stock Index		Russian Stock Index	
Constant	-0.01	-0.01	0.06	0.07
	-0.04	(0.04)	(0.06)	(0.06)
Brazilian dummy-good news	0.001	-0.003		-0.01
	(0.01)	(0.01)		(0.01)
Brazilian dummy-bad news	-.001	-0.01		-0.01
	(0.01)	(0.01)		(0.01)
Russian dummy-good news		-0.01	0.0003	-0.002
		(0.01)	(0.02)	(0.02)
Russian dummy-bad news		-0.02 **	-0.04 **	-0.04 **
		(0.01)	(0.01)	(0.01)
U.S. interest rate	0.003	0.004	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)
DM/U.S. dollar rate (first log difference)	0.22	0.13	0.48	0.49
	(0.43)	(0.43)	(0.61)	(0.61)
U.S. stock index (first log difference)	1.78 **	1.77 **	-0.29	-0.29
	(0.20)	(0.19)	(0.27)	(0.27)
Number of observations	184	184	182	182
Adjusted R-squared	0.31	0.33	0.06	0.05

Source: Central Bank of Brazil; and authors' estimates.

1/ Placement of ** and * denotes significance at 5% and 10% levels respectively.

Table 10. Brazil and Russia: Sovereign Spread Regression Results 1/
(Sample: July 1 - December 30, 1998)

Dependent Variable:	Spreads on Brazilian C-Bond		Spreads on Russian Eurobonds	
Constant	2298.17 **	2252.56	22296.40	21644.52
	(200.88)	(211.83)	(1635.22)	(1727.74)
Brazil dummy-good news	-8.14	22.89		-193.46
	(50.01)	(54.63)		(432.86)
Brazilian dummy-bad news	49.18	29.95		546.48
	(78.62)	(80.38)		(662.17)
Russia dummy-good news		-133.58	-681.40	-1350.23
		(102.00)	(715.33)	(839.73)
Russian dummy-bad news		88.59 *	316.39	450.09
		(47.76)	(345.61)	(392.17)
U.S. interest rate	-282.72 **	-275.99 **	-3822.53 **	-3688.09 **
	(43.00)	(45.24)	(351.66)	(368.66)
DM/U.S. dollar rate (first log difference)	-2866.99	-3435.57	-7776.41	-20296.81
	(2322.46)	(2432.83)	(18956.55)	(19903.28)
U.S. stock index (first log difference)	-1182.91	-1169.30	-549.97	-4432.99
	(1031.68)	(1363.69)	(8442.92)	(11122.13)
Brazilian stock index (first log difference)		90.11		4845.30
		(513.28)		(4147.17)
Russia stock index (first log difference)		201.81		3102.82
		(293.75)		(2405.60)
Number of observations	115	106	117	182
Adjusted R-squared	0.26	0.27	0.50	0.05

Source: Bloomberg; authors' estimates.

1/ Standard error in parentheses; placement of ** and * denotes significance at 5% and 10% levels respectively.

Table 11. Brazil and Russia: Financial Flows Regression Results,
July 1, 1998-January 28, 1999 1/

	Dependent Variable: Floating Market Flows
Constant	0.45
	(2.50)
Brazilian dummy-good news	0.13
	(0.61)
Brazilian dummy-bad news	-1.34 *
	(0.75)
U.S. interest rate	-0.41
	(0.54)
DM/U.S. dollar rate (first log difference)	72.03 **
	(27.68)
U.S. stock index (first log difference)	8.67
	(15.79)
Brazilian stock index (first log difference)	1.33
	(5.01)
Number of observations	128
Adjusted R-squared	0.05

Source: Central Bank of Brazil; and authors' estimates.

1/ Standard error in parentheses; placement of ** and * denotes
significance at 5% and 10% levels respectively.

IV.   Conclusions

The paper investigated the contagion from Russia to Brazil using several sets of data, with different frequencies. We analyzed this case study under two dimensions: players involved and timing of events. A few results are worth highlighting. First, using information from daily movements in two distinct exchange markets we concluded that while the withdrawals in the floating market were present in both the Asian and Russian crisis, they were only followed by withdrawals in the official market in the latter crisis. This induced the larger effect that eventually led to the Brazilian crisis. This contributes to the suspicion that the contagion from Russia was triggered by foreign investors panicking from the Russian crisis.

Second, using weekly data on foreign banks exposure to Brazil, we checked the hypothesis that liquidity needs and withdrawals were one of the channels of contagion. We observed that German banks (known to have had a large exposure to Russia and were badly affected by the Russian crisis) had one of the highest rollover rates within the G7 and, therefore, the data does not seem to reflect a compensatory liquidation of assets story.

Third, from the point of view of lower (monthly) frequencies and aggregated data (total flows), one cannot not observe the contagion effects from the Russian crisis to Brazil..

Fourth, from the dimension of the timing of the events, the comovement between the variables is remarkable, especially with regards to the spreads on Brady bonds. This confirms our findings from previous work (Baig and Goldfajn, 1998) that the correlations in the Brady markets are very high and increase significantly (even after adjusting for the bias) during the crisis. This gives support to the fact that if there was a contagion from Russia to Brazil, the most likely place of the transmission was the off-shore Brady markets.

Fifth, using daily data on several financial data from Bloomberg, one can check the alternative hypothesis that it was the liquidity crisis in mature markets that timed the crisis in Brazil and not the Russian crisis. However, most of the action happens immediately after the Russian crisis both in the foreign exchange and the Brady bond markets, although the spreads on the latter market suffer a new blow during the LTCM crisis. Therefore, rather than concluding in favor of LTCM effect on this market, this leads us to favor the argument that the Brazilian residents reinforced the speculation once they realize that foreign investors had joined the outflow.

References

Agénor, Pierre-Richard, and Joshua Aizenman (1997), "Contagion and Volatility with Imperfect Credit Markets," NBER Working Paper No. 6080, National Bureau of Economic Research, July.

Baig, T. and Goldfajn, I. "Financial Markets Contagion in the Asian Crisis," *IMF Staff Papers*, 46, 167-195.

Calvo, Guillermo (1996), "Capital Inflows and Macroeconomic Management: Tequila Lessons," *International Journal of Finance and Economics,* Vol. 1, July.

Chinn, Menzie (1997), "Before the Fall: Were East Asian Currencies Overvalued?' NBER Working Paper No. 6491 (Cambridge, Massachusetts: MIT Press).

Eichengreen, Barry, Andrew Rose and Charles Wyplosz (1996), "Contagious Currency Crises," CEPR Discussion Paper No. 1453, Center for Economic Policy Research, August.

Forbes, Kristin and Roberto Rigobon (1998), "Measuring Stock Market Contagion: Conceptual Issues and Empirical Tests," Mimeograph, Massachusetts Institute of Technology, April.

Ganapolsky, Eduardo and Sergio Schmukler (1998), "The Impact of Policy Announcement and News on Capital Markets: Crisis Management in Argentina During the Tequila Effect," Mimeograph, The World Bank, February.

Glick, Reuven and Andrew Rose (1998), "Contagion and Trade: Why are Currency Crises Regional?" Mimeograph, University of California at Berkeley, May.

Kaminsky, Graciela and Sergio Schmukler (1998), "What Triggers Market Jitters? A Chronicle of Asian Crisis," Mimeograph, The World Bank.

Masson, Paul (1997), "Monsoonal Effects, Spillovers, and Contagion," Mimeograph, International Monetary Fund.

Ostle, Bernard and Linda Malone (1988), *Statistics in Research,* Iowa State University Press, Iowa.

Pindyck, R. and J. Rottemberg (1990), "The Excess Co-Movement of Commodity Prices," *Economic Journal*, Vol. 100, No. 4.

Sachs, Jeffrey, Aaron Tornell, and Andres Velasco (1996), "Financial Crises in Emerging Markets: The Lessons from 1995," NBER Working Paper No. 5576, National Bureau of Economic Research, May.

Valdés, Rodrigo (1997), "Emerging Markets Contagion: Evidence and Theory," Documentos de Trabajo del Banco Central, Central Bank of Chile.

APPENDIX I: Data Used in the Paper

- For the Brazilian stock market, we take daily closing figures from the Bovespa index, and convert them to US dollars by the end-of-day exchange rate. For Russia, we do the same, using the Moscou index. Converting the indices in dollars allows us to make keep our analysis uniform before and after the devaluation of the currencies. Source: Bloomberg

- For sovereign bonds, we use the spreads on the Brazilian C-Bond and the Russian Euro-bond (EB Russo - 2001). The spreads were calculated by subtracting the yield to maturity of treasury bill with same duration from yield to maturity of the respective bonds: Brazilian C-Bond; maturity: 4/15/2014, coupon: 8% variable – 6 months. Russian Eurobond; maturity: 11/2001, coupon: 9.25% fixed – 6 months. Source: Bloomberg.

- Financial flows are the balance of the foreign exchange transactions in the financial markets. Ultimately the government would have to balance the market balance in order to keep the exchange rate crawling peg. However, the changes in reserves do not necessarily track down exactly the financial exchange flows because some of the transactions are settled with a lag period (30-days and so). Source: Central Bank of Brazil.

- The Central Bank of Brazil follows the maturing short term external liabilities of its banking system in a weekly basis. The short term obligations include interbank and credit lines. This survey based monitoring system was introduced on October 1998, after the Russian crisis and during the negotiations with the IMF

- BIS exposure data obtained from their semi-annual reports on www.bis.org

- Daily interest rates and exchange rates from Bloomberg.

- News dummies created by the authors using news obtained from Bloomberg.

APPENDIX II: Procedure for creating the dummy variables

The dummy variables were created by following a strict filtering process:

1. We began by collecting daily financial news for Brazil and Russia. Our sources were Reuters daily wire and Bloomberg update. The goal was to separate news that truly represent fundamentals from news that are mostly noise, or an attempt of the news writer to somehow explain the movement in the market in the absence of any major events. We broke down the raw news for each country.

2. For each country, the news were separated into unambiguous "good" and "bad" news categories. Distinction between good and bad news was made by using simple guidelines—credible attempts to re-structure the economy were deemed well, whereas any news that represents further deterioration of the financial or real sector were designated as bad. At this point, we had ten lists of raw good and bad news for the five countries under study ready to be filtered. The filtering was done by the following criteria:

3. For *good news*, we ignored the given explanations of why the market did better and instead focused on news that met any of the following criteria:
    *   Successful formation of bailout arrangements;
    *   Announcement of rescue package by international organizations;
    *   Better-than-expected economic news (GDP growth better, inflation lower, etc.);
    *   Specific measures to stabilize the markets.

4. For *bad news*
    *   Collapse of the currency regime or of long-standing financial arrangements;
    *   Breakdown in negotiation with multilateral agencies;
    *   Large scale bankruptcy or firm closure;
    *   Credit rating downgrade;
    *   Worse than expected announcements about debt exposure, inflation, growth, confusing policy moves;
    *   Threats or announcement of capital controls imposition;
    *   Resignation or firing of high profile officials;

5. Using the good and bad news series for each country we constructed two series of dummy variables. On the dates there were good (bad) news we placed a number one on the good (bad) news dummy series. Otherwise, we placed a zero on that date.

6. We avoided typical biases in the presentation of news by the agencies. We ignored typical market commentary statements like "there was widespread pessimism among the traders today." We also avoided focusing on the actual movement in the financial markets for a given day. We simply included news that fell into any of the above categories instead of finding good news on days the markets went down and vice-versa.

7. News that came out at the end of a business day were dated the following day.

The news items were checked across the different sources to verify date and content.

APPENDIX III : Forbes and Rigobon (1998) adjustment

Fobers and Rigobon (1998) show that the estimated correlation between two stochastic variables, *x* and *y*, increases when the variance of *x* increases—even if the actual correlation between *x* and *y* does not change. The standard, unadjusted correlation coefficient is conditional on the variance of *x*. They show that the bias can be quantified as follows:

$$r_t^u = r_t \sqrt{\frac{1+d_t}{1+d_t r_t^2}}$$

where,

r_t^u : *unadjusted correlation coefficient*

r_t : *actual correlation coefficient*

d_t : *relative increase in* var*iance of* x_t

Manipulating the above equation yields:

$$r_t = \frac{r_t^u}{\sqrt{1+d_t[1-(r_t^u)^2]}}$$

We use the above methodology to adjust the above methodology to adjust the crisis period correlations.

APPENDIX IV: News chronology

Good News: Russia

July 14: The Yeltsin government said on Sunday that it had reached agreement with the International Monetary Fund on a multi-billion-dollar package to stabilize Russia's financial markets.

August 7: Russia will receive the first $300 million of its third $1.5-billion structural adjustment loan from the World Bank on Monday. At a meeting in Washington Thursday the board of directors of the World Bank voted unanimously to release the loan to Russia on the terms agreed to earlier.

Sept. 10: The Kremlin confirmed that President Boris Yeltsin had decided to ask parliament to approve Acting Foreign Minister Yevgeny Primakov as Russia's new prime minister. Communists, liberals and politicians close to President Boris Yeltsin showed rare unity in praising Primakov and predicting rapid approval by parliament in a vote scheduled for Friday.

Oct 14: Prime minister Primakov says banking reform is a priority, and scraps the 3 percent import tax, 10 percent VAT on food.

Nov 7: After weeks of tense negotiations, Moscow persuaded foreign creditors to accept ruble-denominated securities as part of a restructuring plan of its frozen $40bn treasury bill (GKO) market. In return, the finance ministry dropped its insistence on including Russian commercial banks' outstanding forward dollar contracts in the plan.

Feb 8: Russia is to let foreign holders of frozen government rouble debt use all the proceeds of new debt received in a swap to buy shares on the MICEX.

Feb 10: Russia will drop its 3% import duty in March in keeping with a Wednesday decision of the government commission on preventive measures in foreign trade and customs.

Feb 18: The Russian government plans to halve duties on some exports to stimulate foreign investment, the country's customs chief announced today. Also, The German government is prepared to reschedule remaining Soviet-era debt with Russia as part of a show of "economic solidarity" with the crisis-hit country, the head of the German Chancellor's economic policy department said.

Feb 25: Russia expects to collect over 16 billion roubles ($700.5 million) in cash taxes in February, slightly more than the target.

Bad News: Russia

August 6: Deputy finds Duma approval of 1999 budget unlikely -- The government-proposed 1999 federal budget will not be approved by the State Duma through regular debate procedures, according to Duma Budget committee chairman Alexander Zhukov (Russian Regions).

Aug 10: Russia's Finance Ministry canceled Wednesday's government paper auctions at which it had planned to offer six billion roubles of new issues, citing poor market conditions, a ministry official said on Monday.

Aug 11: In late trade on Monday, benchmark front month Brent crude oil futures on the International Petroleum Exchange in London slid to trade for the last time at $11.90 per barrel, equaling 10-year lows set in March. This not only affects Russia's revenues from oil exports but jeopardizes other areas of the economy by making Russia less attractive to foreign investors.

Aug 13: In the face of an unprecedented liquidity crisis, the Russian central bank imposes limits on foreign exchange purchases and increases access to overnight credit.

Aug 17: The rouble was allowed to float freely within the bounds of a new corridor expanded to 6.00/9.50 to the dollar from 5.27/7.13 previously. Also, a 90-day moratorium was declared on some foreign debt servicing.

Aug 18: Moody's Investors Service downgraded its ratings on all Russian corporate foreign debt issuers to Caa1 and the ratings remained on review for further possible downgrade.

Aug 27: In the middle of exchange rate volatility, the Russian government s offer for the restructuring of its frozen GKO Treasury bills find no buyers in the market.

Aug 28: President Boris Yeltsin dismisses reformer Anatoly Chubais from the post of Russia's top negotiator with international financial institutions. Chubais, formerly Russia's privatization chief, played a key role in winning a multi-billion dollar loan from the International Monetary Fund in July.

Sept 15: As a compromise to the political showdown of last week, President Yeltsin hires a group of Gorbachev era economists.

Sept 24: Russian federal budget revenues dropped significantly in the first three weeks of September due to the country's payments crisis, the finance ministry said. The central bank announced that reserves had fallen to $12 billion.

Sept 25: The government press service confirmed that the sale of a 75 percent plus one share stake in Rosneft, the last big oil company still in state hands, had been scrapped. Rosneft had earlier failed to sell at $2.1 billion and again at $1.6 billion. In a further blow Gazprom, Russia's biggest company and tax payer and the world's biggest gas company,

said it was cutting tax payments to two billion roubles a month from the 3.5 billion it had been due to pay.

Sept 28: A spokesman for the All-Russian Insurers' Union said that the crisis would pare down the number of insurers to 300-400 companies from 1,400 now and that even a few major firms would fail. Also, suits were filed against Lehmann Brothers after the investment bank froze assests of Inkombank and UNEXIM bank for not honoring debt obligations.

Oct 1: The World Bank said that previous plans to lend Russia $6 billion was now in doubt given the changed market conditions.

Nov 20: Russian Deputy Finance Minister Mikhail Kasyanov said on Friday that his cash-strapped nation would be able to repay less than $10 billion out of $17 billion of foreign debt due next year.

Dec 1: Russia's Interdepartmental Commission for Export Pipelines and Sea Terminals suspends the issue of export documents to four oil companies. Also, Sberbank announced that due to lack of cash and other "technical difficulties," depositors will have to wait until some future date to have finally gained access to their savings after transferring their accounts from failing commercial banks to Sberbank.

Dec 3: Deposits in Russian banks fall 15% from August levels. FDI falls 14% from a year ago.

Dec 4: Inflation in Russia was 65.3% from January to November, compared with just 10% in the same period last year, reported the State Statistics Committee.

Dec 11: The Russian federal government in January-October earned 1.425 billion rubles from privatization, just 17.5% of an annual target of 8.12 billion rubles.

Dec 17: Russia is not interested in allowing nonresidents to acquire shares in companies for the new OFZ federal bonds that they will receive in exchange for currently frozen GKO Treasury bills and OFZ, said Finance Minister Mikhail Zadornov.

Dec 28: New reports from the State Statistics Committee shows that Russian gross domestic product shrank by 3.3% in the first nine months of the year to 1.88 trillion rubles, and not 3% as reported earlier.

Dec 29: In a pessimistic assessment of the government's economic policies, Boris Fyodorov, the country's former tax chief, said that Russia's federal tax receipts could drop by as much as 50% in 1999.

Dec 30: Russia has missed a $360 million dollar payment due on its Soviet-era debt, the paying agent for the debt said today.

Jan 11: Western banks said that they were no longer in talks on the GKO restructuring deal and were studying prospects for legal action to force better terms.

Jan 12: Russia's chief prosecutor on Monday said that government officials may have illegally used a $4.8 billion loan from the IMF the country received in July.

Jan 13: Russia s fuel ministry slammed planned oil export tax; A spokesman said the ministry was "categorically against" the plan s of the energy ministry to introduce export tariffs on oil products. Also, Fitch IBCA said on Wednesday it had downgraded the long-term foreign currency rating assigned to Russia's PRIN bonds to DD from CC.

Jan 29: Russia's troubled Uneximbank told creditors on Thursday it could not pay interest on a $50 million international bond, raising fears it will become next week the first Russian borrower to default on a Eurobond.

Feb 3: Yamburggazdobycha, the largest production unit of Russian gas giant Gazprom is facing a bankruptcy hearing in a dispute over unpaid promissory notes. Also, some 60 percent of Russia's top 17 banks have assets which are worthless, the head of once-leading bank SBS-Agro was quoted on Wednesday as saying.

Feb 5: Rating agency Standard & Poor's said on Friday that cash-strapped Russia may start to miss payments on its Eurobonds later this year although the country has pledged to meet all payments on this debt.

Feb 9: The International Finance Corp, a key provider of finance for Russia's private sector, has been forced radically to scale down plans for 1999. Also, Rating agency Standard & Poor's has said that a downgrade of Russia's foreign debt "could occur in the near future" if the country does not receive new external loans or if the government does not take other steps to "shore up its foreign-exchange position."

Good News: Brazil

July 9: Pedro Parente announces the reduction of the IOF(financial tax), 15% to 16%, to stimulate demand.

July 29: Privatization of Telebrás raises R$ 22 billions to the government.

August 5: Annual inflation rate (0,97%) is the lowest in 49 years.

August 12: Government reduces import taxes on capital goods.

August 22: Central Bank of Brazil auctions dollar-linked bonds to calm the markets.

August 24: Government passes legislation stimulating capital inflows.

September 8: Government announces spending cuts of R$ 11 billions.

October 5: FHC is reelected.

October 21: IMF and the Brazilian Government announce an agreement on 3-year fiscal targets.

October 22: An IMF-Brazil program is announced.

October 26: World Bank announces US$ 4 or 5 billions of financial help.

October 28: Fiscal adjustment plan is announced.

November 13: IMF's program amounts to US$ 41 billions to Brazil.

November 18: Congress approves an important social security reform measures.

December 9: Senate approves agreement with the IMF.

January 7: Brazil receives US$ 1 billion from World Bank to reform social security.

February 12: Brazilian treasury pays for Minas Gerais eurobonds.

February 26: Arminio Fraga is appointed the new president of the Central Bank.

March 10: Important financial tax, CPMF, is approved by Congress in the 1st round.

March 16: Brazil reduces capital inflow tax from 2% to 0,5%.

March 18: Congress approves CPMF on second round.

March 29: Current account's deficit falls to US$ 924 millions.

March 31: IMF approve new and more ambitious version of fiscal adjustment.

April 9: Itau Bank issues US$ 150 millions in international markets.

April 19: Brazil announces it will issue 5 year global bonds, partly in exchange for Brady bonds.

April 23: Government announces a R$ 7,1 billions budget surplus in 1Q99.

April 30: Agriculture production forecast for 1999 is 7,37% over 1998.

June 1: Exports grow 19% in May and trade surplus reaches US$ 312 millions. Also, unemployment falls in April to 8,78%.

June 7: Industrial production falls only 0,3% in April.

June 22: IMF revises forecast of GDP growth to -1,2% for this year.

Bad News: Brazil

July 1: May has the highest level of unemployment (8,2%) in 14 years.

September 4: Moody's downgrades Brazilian sovereign and corporate debt.

November 11: Industrial production falls 2,4% in September.

November 24: J.P. Morgan announces that they forecast that Brazilian economy will decline 4,3% in 1999.

December 3: Congress vote against important social security measure.

January 6: State of Minas declares unilateral moratorium.

January 13: Central Bank governor Gustavo Franco resigns.

January 28: Announcement that the level of industrial employment fell 1,2% in November.

January 29: Bank runs. Finance Minister Malan announces that there will be no deposit freeze.

February 10: State of Minas defaults on its eurobonds.

February 19: GNP grows only 0,2% in 1998.

February 23: Panic. Exchange rate brakes R$ 2,00 level.

March 8: Important food company, Sadia, adjusts prices by 18%.

March 17: Federal judges on strike, demanding higher wages.

March 24: Bank scandal: Brazilian revenue service investigates bank's profits from devaluation.

March 24: Brazil announces it will adopt inflation targeting in the beginning of June.

April 1: Central Bank investigates allegation of leaks before January's devaluation.

April 12: Congress creates committee to investigate allegation of inside information in the banking system.

May 17: Brazilian government revise downwards trade surplus forecast for 1999.

May 27: Unemployment level reaches 20% in São Paulo.

May 31: Government losses in court.

June 9: Energy prices increase by 14%.