Statistical Evidence of Contagion in Emerging Markets

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Abstract

The object of this paper is to use the available literature on financial crises to explain the possible existence of contagion effects in Latin America stemming from the Asian crisis and the devaluation of the ruble. This paper empirically tests for evidence of contagion in the exchange rates, equity markets, and emerging market bond indices of Latin American countries. A three-year period covering January 1, 1996 to December 31, 1998 is studied, by dividing it into two equal segments. The former period is referred to as the tranquil period, and the latter is the crisis period as it hosts both the Asian and the Russian crises. A comparison is made between the correlation coefficients among the various financial markets in Latin America during crisis and tranquil times. If there is no significant increase in the pair-wise country correlation coefficients between the two periods then it is likely that the pressure felt by the markets in Latin America were due to some common cause effects. However, if the increase in correlation is significantly higher than the historical correlation, then there is reason to suspect that investor sentiments have shifted. We use on-parametric bootstrap tests to quantify the increase in correlation and we visulalize this increase by means of a principal component analysis which gives a data driven way to show the desired effect. Our results a change in investor behavior as a reflection of pessimism leading to selling off equities in several emerging markets in order to raise cash to be able to meet expected increases in redemption in other markets.

INTRODUCTION

A notable number of financial crises have been experienced by economies in various regions of the world in recent years. Especially, the same two decades that have seen spreading financial liberalization and ever-growing global capital flows have also witnessed these crises, which have imposed serious real costs on the affected economies. In the 1990's, financial crises first hit Europe, when several currencies in the Exchange Rate Mechanism (ERM) of the European Monetary System experienced speculative attacks during 1992-1993. Next, Mexico experienced the "tequila crisis", with the collapse of the peso in December 1994. The third currency and financial crisis of the 1990's, was triggered by the devaluation of the Thai baht on July 2, 1997. Economic upheaval spread throughout Southeast Asia, especially in Indonesia, Malaysia, the Philippines, Korea, and Thailand. Finally, August 17, 1998 marked the beginning of the Russian currency crisis.

In all four episodes, financial crises have involved significant international spillovers. In some cases, the next victims have been neighbors and trade partners; in others they have been countries that have shared similar policies or have suffered common economic shocks. At times, as in the summer of 1998, changes in investor sentiments and increased aversion to risk contributed to contagion within and across regions. A key problem is that financial markets tend, in the face of such shocks, to be characterized by panic and herd instinct, and fail to discriminate between economies with strong and weak fundamentals. [1] In a number of cases, therefore, financial crises have required international financial assistance to limit their severity and costs and to contain their contagious spread and spillovers to other countries.

Latin America during the Crises

Until the Russian crisis broke out in August 1998, most of the emerging markets in Latin America had weathered the turmoil in financial markets reasonably well. A broad range of measures, including increases in interest rates, to help defend the exchange rates, and a tightening of fiscal policies lessened the effects of financial stress during the Asian crisis. In fact, when the Asian crisis caused the first currency depreciation in July and August 1997, and depressed stock markets in Thailand, the Philippines, Malaysia and Indonesia, no significant effects were perceptible in Latin America. Capital inflows were sustained at relatively high levels and growth prospects had deteriorated only moderately. Only, Venezuela, Chile, and to some extent Mexico, were more seriously affected than their neighbors, due to weakening prices of export commodities.[2]

However, with Russia's unilateral debt restructuring, the financial market pressures intensified in most of the markets in the region. The Latin American economies, which had continued securing relatively large inflows of private capital in the wake of the Asian crisis, appeared now to have been affected the most by the dramatic deterioration in market sentiment. A sharp downturn in equity markets in the United States and other G7 countries did not help restoring investor confidence in emerging markets. During late August and early September, Brazil and Venezuela faced a downgrade of credit ratings, sovereign bond spreads widened dramatically reaching levels not seen since the "tequila crisis", and equity prices fell by 40 to 60 percent off their highs. Contagion from Asia and Russia may in part explain the financial market pressures that arose in Latin America together with the country-specific factors, including macroeconomic imbalances and structural weaknesses unrelated to the crisis, as well as political uncertainties.

The contagious spread of turmoil from Russia to Brazil and other Latin American countries caused investors to withdraw capital indiscriminately from most emerging market economies regardless of their strength. As demonstrated in Table 1, emerging markets, including Latin American countries, experienced a sharp reduction in gross capital flows during the first half of 1998 and especially in the months that followed the Russia's moratorium on debt servicing in August 1998. The impact in Latin America was felt severely because private flows, which were reduced by a fifth, had financed a large increase in external deficits through 1996 and 1997.

Capital Flows to Emerging Markets Collapse in 1998

(US$ billions, monthly averages)

Region	1996	1997	Jan. - June 1997	July - Dec. 1997	Jan. -June 1998	July - Sept. 1998
All developing countries	204.60	290.95	141.04	149.92	104.03	33.46
East Asia and Pasific	71.51	74.69	41.75	32.94	12.79	6.64
South Asia	10.40	12.55	6.05	6.50	2.37	0.15
Europe & Central Asia	26.46	51.41	25.43	25.99	25.06	9.47
Latin America	83.99	121.59	58.99	62.60	55.69	11.59
Middle East	5.05	20.22	5.56	14.66	5.50	5.12

Source: World Bank, GEP 1998

Table 1.1

Although the major Latin American economies were structurally much stronger than the Russian economy, investors wanted to avoid risk everywhere. Emerging market sovereign spreads over U.S. Treasuries rose above 1,500 basis points (15 percentage points) by September at the peak of the Russian crisis. The increase in interest rate spreads reflected the increased risk premia, resulting in a sharp slowdown in inflow of private capital to Latin America.

Widening Spreads on Brady Bonds in Latin America

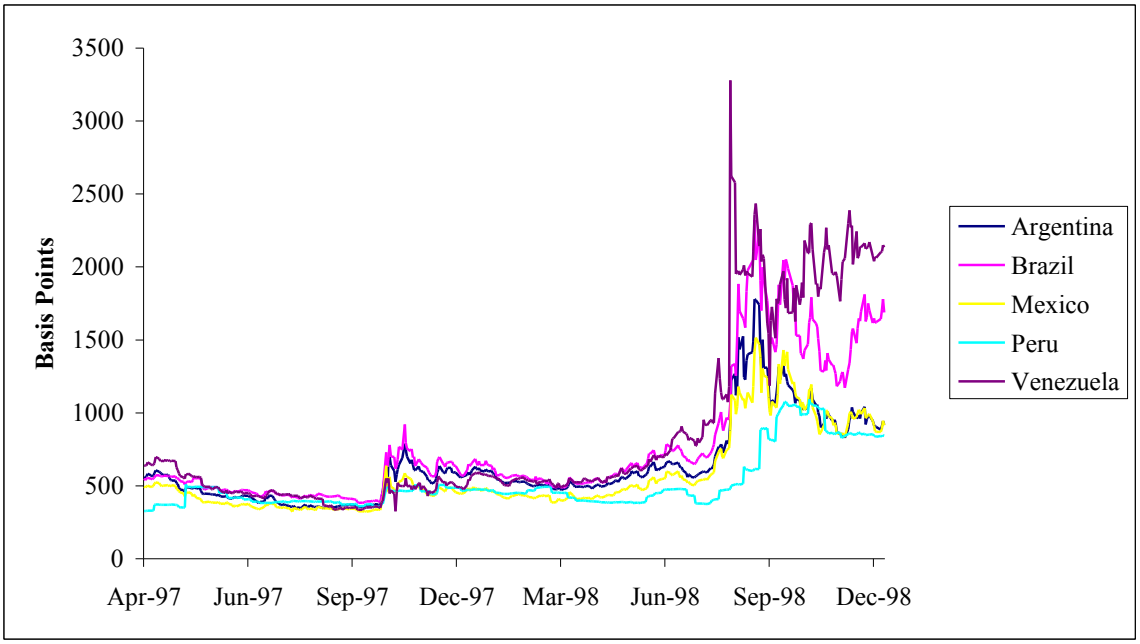

Figure 1.1

Previous literature on contagion has dealt in detail with qualitative explanations for the possible roots of contagion in emerging markets, however it is important to support its existence empirically as well. Therefore, the following two sections will use the non-parametric bootstrap and the principal component analysis to test for contagion in Latin America during the Asian crisis and after the default of Russia in August 1998.

CORRELATION ANALYSIS

A three-year period spanning from January 1, 1996 to December 31, 1998 is analyzed to determine the pairwise country relationships between Latin American countries. To distinguish the effects of contagion, the study period is divided into two equal segments with the first starting at January 1, 1996 and continuing until June 30, 1997, and the second extending from July 1, 1997 to December 31, 1998. These periods will be referred to as the tranquil and the crisis period, respectively. The time frames are selected so that the crisis period contains both the Asian and the Russian crises and the tranquil period covers a relatively quiet period, in terms of global economic turbulence, with the same duration.

The object of the empirical analysis is to prove that there is a significant increase in the pairwise correlation coefficients in the daily changes of stock market indices, the emerging market bond indices, and the exchange rates in Latin America countries during the crisis period as compared to the tranquil period. These time series are used to capture the consequences of the financial effects, as well as the international effects caused by contagion that lead to a fall in asset prices, capital outflows from emerging markets, and speculative attacks on currencies. In appendix A, one can get a comparative idea about the behaviour of these time series during the crisis and tranquil phases. In the figures, the declines in stock market prices, higher interest rates to compensate higher risk premia, and the upward pressure on exchange rates during the crisis period as compared to the tranquil period in Latin America can be observed.

2.1 Stock Market Index Correlation

Our first step will be to estimate correlation coefficients of the daily changes, calculated as the $\ln(P_{t+1} / P_t)$, in stock market indexes in Latin America and Russia during the crisis period. For each country, the national index with the highest trading volume is chosen in order to capture the international investor sentiment. The crisis period, as described above, begins from the day of the baht devaluation, July 2, 1997 and extends until December 31, 1998. This period includes both the Asian and the Russian crisis.

The full sample shows positive correlationcoefficients for all pairs. (Table 2.1) Within Latin America all pairs have coefficients of .34 or higher. Argentina's cross-correlations with the other countries stands out, with correlation coefficients of its daily change in stock market indexes with Brazil, Chile, Mexico, Peru, Venezuela and Russia being .78, .56, .72, .47, .39, and .19, respectively. Brazil also has cases of sizable correlation coefficients with Mexico and Chile, which stand at .71 and .51, respectively. Russia, with no geographical proximity to Latin America, has correlation coefficients with Chile and Peru of .25.

Correlation Coefficients for Stock Market Indices

July 1, 1997 to December 31, 1998						
	Argentina	Brazil	Chile	Mexico	Peru	Venezuela
Brazil	0.78					
Chile	0.56	0.52				
Mexico	0.72	0.70	0.52			
Peru	0.47	0.44	0.46	0.50		
Venezuela	0.39	0.34	0.40	0.34	0.34	
Russia	0.19	0.07	0.25	0.10	0.25	0.16

Table 2.1

The problem with using the full sample is that it smooths out a lot of shorter duration interactions that exist in markets in times of heightened investor herd behaviour. For example, parameters that result from extreme market behaviour exactly around the time of the arrival of crisis news are diminished by the use of the full sample. Therefore, after calculating the overall correlation in the sample period, the correlation coefficient analysis is extended for sub-samples consisting of three-month windows, and rolling them to the end date in order to take a deeper look at the dynamics of cross-border correlation. There are six rolling panels, which are interesting to analyse. The first four rolling panels below capture the second half of 1997 which hosts the baht devaluation in early July and then the collapse of the Hong Kong SAR. During this period the market reaction of funds was to draw money out of developing countries causing huge declines in asset prices. The coefficients in the four panels are increasing steadily as the year end approaches. Argentina, Brazil, and Mexico have the highest cross-country correlation coefficients in the rolling time windows as they make up 45% of the net private flows into Latin America during the 1990 – 1997 period. As a result, any change in investor sentiment gets easily reflected in these markets. Levels above .80 are observed during this time period. The correlation coefficients between Russia and Chile, go as high as .42 during the Asian crisis which reflects the ultimate effects on low oil prices due to recession in Asia.

July 1, 1997 to September 31, 1997						
	Argentina	Brazil	Chile	Mexico	Peru	Venezuela
Brazil	0.69					
Chile	0.50	0.40				
Mexico	0.50	0.47	0.56			
Peru	0.36	0.40	0.30	0.30		
Venezuela	0.29	0.29	0.14	0.13	0.27	
Russia	0.32	0.28	0.41	0.32	0.32	0.24

August 1, 1997 to October 31, 1997						
	Argentina	Brazil	Chile	Mexico	Peru	Venezuela
Brazil	0.82					
Chile	0.45	0.34				
Mexico	0.79	0.72	0.53			
Peru	0.65	0.63	0.44	0.71		
Venezuela	0.68	0.64	0.44	0.62	0.61	
Russia	0.10	0.11	0.41	0.00	0.24	0.21

September 1, 1997 to November 30, 1997						
	Argentina	Brazil	Chile	Mexico	Peru	Venezuela
Brazil	0.83					
Chile	0.48	0.49				
Mexico	0.83	0.77	0.55			
Peru	0.64	0.69	0.58	0.73		
Venezuela	0.59	0.63	0.59	0.60	0.76	
Russia	0.18	0.18	0.42	0.08	0.26	0.26

October 1, 1997 to December 31, 1997						
	Argentina	Brazil	Chile	Mexico	Peru	Venezuela
Brazil	0.84					
Chile	0.50	0.44				
Mexico	0.84	0.79	0.52			
Peru	0.66	0.68	0.62	0.74		
Venezuela	0.58	0.62	0.56	0.59	0.74	
Russia	0.22	0.20	0.37	0.07	0.29	0.29

Table 2.2

The other two sliding windows that reveal high correlation above are the windows starting July 1, 1998 and August 1, 1998. They capture a total of four month period around the Russian crisis period. Almost all pair-wise coefficients rise during these periods with Brazil, Argentina, and Mexico coefficients again reaching values above 0.80. Surprisingly, the cross-country

coefficients between Argentina, Brazil, Mexico, and Russia during this period don't reveal high correlations. However, there is a significant relation between Venezuela, Chile, Peru, and Russia throughout the crisis period, possibly due to their mutual dependence on oil revenues and the continuation of the decline in prices in this commodity.

July 1, 1998 to September 31, 1998

	Argentina	Brazil	Chile	Mexico	Peru	Venezuela
Brazil	0.84					
Chile	0.71	0.73				
Mexico	0.75	0.82	0.70			
Peru	0.57	0.48	0.60	0.65		
Venezuela	0.51	0.50	0.62	0.49	0.53	
Russia	0.11	-0.13	0.11	0.05	0.23	0.18

August 1, 1998 to October 31, 1998

	Argentina	Brazil	Chile	Mexico	Peru	Venezuela
Brazil	0.88					
Chile	0.76	0.72				
Mexico	0.80	0.82	0.74			
Peru	0.56	0.46	0.61	0.66		
Venezuela	0.56	0.46	0.63	0.48	0.57	
Russia	0.13	-0.07	0.12	0.08	0.24	0.14

Table 2.3

Below are graphs showing the evolution of rolling three-month correlation coefficients between countries during the three-year period under investigation. As observed, the correlation coefficients between Brazil & Argentina and Brazil & Mexico exhibit an increased co-movement after July 1997. This coincides with the beginning of the crisis period. However, the same plots with Mexico & Colombia and Chile & Peru do not reveal the same feature. A deeper analysis of the rolling correlation will be done in the last section.

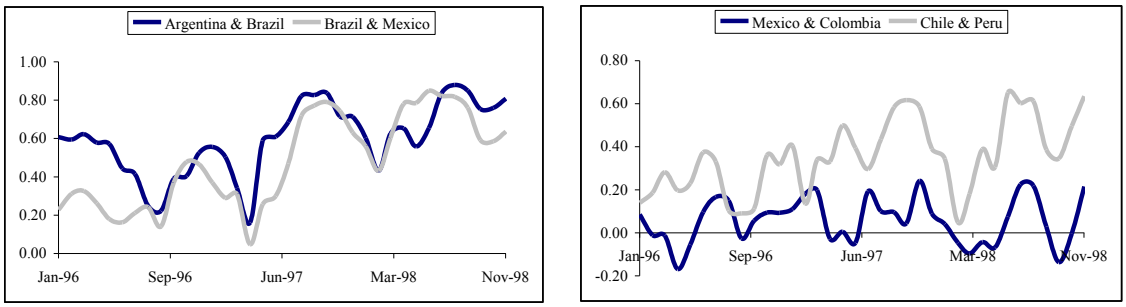

Figure 2.1

2.2 Emerging Markets Bond Index Correlation

We now perform the same type of sliding window cross correlation analysis on the emerging market bond indexes, introduced by JP Morgan in 1995. This index tracks total returns for traded external debt instruments in the emerging markets. Included in this index are the U.S. dollar and other external-currency-denominated Brady bonds, loans, Eurobonds, and local market instruments for the participating countries.[3]. Chile is excluded from this analysis because of lack of data. This index provides a better study of interest rates in Latin America because for each country's macroeconomic policies intervene in the determination of overnight call rates during crises periods. Countries have different national policy approaches in reacting to the financial crisis. The index, however, captures the increased interest rates to prevent large sums of capital outflow and to prevent attacks on currency. The risk premia incorporated in higher yield levels during the financial crisis results in declines in bond prices that gets reflected in the fall of the index.

The full sample panel (Table 2.4) with cross-border correlations for changes in emerging market bond indexes reveal high level of co-movement in the five Latin American countries that have taken part in the Brady plan. Due to the nature of its construction, the EMBI daily returns are

much more highly correlated across all Latin American countries. All pairs reveal high positive coefficients with Argentina at level .93, .88, .74, .70 with Brazil, Mexico, Peru, and Venezuela, respectively. Russia also supports investor herd behaviour with coefficients between .47 and .54 during the crisis period.

CORRELATION COEFFICIENTS FOR THE EMBI

July 1, 1997 to December 31, 1998					
	Argentina	Brazil	Mexico	Peru	Venezuela
Brazil	0.93				
Mexico	0.88	0.85			
Peru	0.74	0.75	0.69		
Venezuela	0.70	0.71	0.65	0.63	
Russia	0.51	0.54	0.53	0.47	0.47

Table 2.4

Computijng the correlation coefficients in three month sliding windows as before, one observes even higher levels. (Table 2.5) Argentina and Brazil reach a value equal to 0.96 during two of the three month rolling windows that portray the index during the height of the Asian crisis. Changes in Russia are also highly correlated with Latin America during the peak times of the Asian crisis. Similarly the two windows in the bottom that portray the Russian crisis reveal high levels.

July 1, 1997 to September 31, 1997					
	Argentina	Brazil	Mexico	Peru	Venezuela
Brazil	0.90				
Mexico	0.92	0.91			
Peru	0.59	0.59	0.58		
Venezuela	0.79	0.82	0.87	0.72	
Russia	0.41	0.42	0.38	0.20	0.23

August 1, 1997 to October 31, 1997					
	Argentina	Brazil	Mexico	Peru	Venezuela
Brazil	0.96				
Mexico	0.94	0.87			
Peru	0.87	0.90	0.83		
Venezuela	0.97	0.91	0.97	0.88	
Russia	0.82	0.83	0.80	0.82	0.83

September 1, 1997 to November 30, 1997					
	Argentina	Brazil	Mexico	Peru	Venezuela
Brazil	0.96				
Mexico	0.93	0.86			
Peru	0.86	0.88	0.78		
Venezuela	0.96	0.91	0.96	0.86	
Russia	0.78	0.81	0.69	0.83	0.80

October 1, 1997 to December 31, 1997					
	Argentina	Brazil	Mexico	Peru	Venezuela
Brazil	0.95				
Mexico	0.93	0.85			
Peru	0.87	0.88	0.80		
Venezuela	0.96	0.91	0.96	0.86	
Russia	0.78	0.82	0.69	0.80	0.78

July 1, 1998 to September 31, 1998					
	Argentina	Brazil	Mexico	Peru	Venezuela
Brazil	0.96				
Mexico	0.90	0.89			
Peru	0.79	0.79	0.74		
Venezuela	0.68	0.74	0.66	0.69	
Russia	0.53	0.55	0.58	0.52	0.48

August 1, 1998 to October 31, 1998					
	Argentina	Brazil	Mexico	Peru	Venezuela
Brazil	0.95				
Mexico	0.88	0.89			
Peru	0.76	0.76	0.69		
Venezuela	0.68	0.73	0.63	0.66	
Russia	0.51	0.50	0.55	0.46	0.43

Table 2.5

Following the analysis in the previous section the graphs for the rolling window correlations of four couples of countries are presented below. The Brazil & Peru and Argentina & Peru pairs support the idea of increased correlation coefficients following the baht devaluation in July 1997. However, the second graph does not demonstrate a similar feature. In fact, the pairs Argentina &

Venezuela and Mexico & Venezuela show similar and even lower values of coefficients for the crisis periods as compared to tranquil periods.

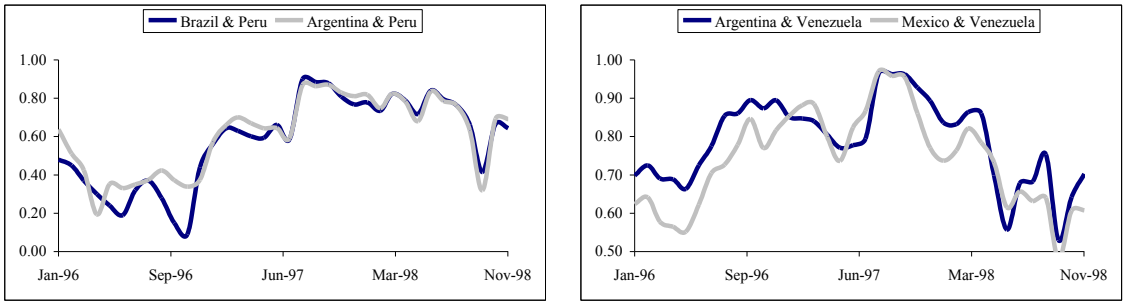

Figure 2.2

2.3 Exchange Market Correlation

The last data set for which the correlation coefficients of the daily changes are calculated is the nominal exchange rates vis-à-vis the US$. Although the full sample does not portray strong positive correlation coefficients for all cross-country pairs, the analysis should be made with some reservations. Since exchange rates are directly affected by interest rates, which are widely used as tools of monetary policy in all the countries in discussion, the exchange rates reflect the policy stance rather than market determined levels in some countries. This is especially the case with Argentina that has successfully maintained a fixed exchange rate with the US dollar. Out of its six pairs, Argentina has three negative coefficients and three insignificant ones, which reflects the lack of market determined levels. Similarly, Venezuela has tried to maintain a tight exchange rate band, together with Russia before the ruble started to float at a wider band. However, pressures in oil prices and investor sentiment has come to light little after the Russian default where the bolivar has depreciated more than 15% and the ruble has depreciated more than 200%.

For countries with relatively floating exchange rates the full sample panel shows coefficients of .22, .43, .50 between Mexico and Brazil, Chile, and Peru, respectively. These values suggest significant co-movement levels among the Latin American countries during the times of crisis. When the rolling windows are analyzed there is a significant increase in these coefficients again.

CORRELATION COEFFICIENTS FOR EXCHANGE RATES

July 1, 1997 to December 31, 1998							
	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Venezuela
Brazil	-0.11						
Chile	-0.04	0.11					
Colombia	0.01	0.04	0.00				
Mexico	-0.03	0.15	0.40	0.08			
Peru	0.14	0.03	0.27	0.01	0.48		
Venezuela	0.06	-0.03	-0.03	-0.02	0.08	0.01	
Russia	-0.05	-0.04	0.00	0.13	0.01	0.05	-0.05

Table 2.6

It is still interesting to look at countries with freely floating currencies, among which are Mexico, Chile, Colombia, and to some extent Venezuela. Argentina, Brazil, and Russia are taken out because of their tight monetary policies, which do not reveal a clear picture of the market

behaviour. Table 2.7 shows the same rolling windows out of which the first four depict the second half of 1997 and the last two demonstrate the correlation coefficients around the default of Russia. As mentioned in the introduction, Latin American countries are not impacted at a high level in the beginning of what is called the Asian crisis. This can be observed by the first two rolling windows, which reflect a jump from 0.01 to 0.88 for the correlation between Mexico and Chile. Similarly levels between Mexico and Peru leapt from a negative coefficient at –0.18 to 0.76 and the correlation between Peru and Chile rose from –0.14 to 0.75. For all the pairs that are just mentioned the values remain at high positive values until the end of 1997.

Although Venezuela dominantly has negative or small values throughout the sample period, it reaches high levels during the Russian crisis and has coefficient .20 and .22 with Chile and Mexico, respectively. However, overall pair-wise correlation has been higher during the Asian crisis as compared to the height of the Russian crisis.

July 1, 1997 to September 31, 1997				
	Chile	Colombia	Mexico	Peru
Colombia	-0.08			
Mexico	0.01	0.07		
Peru	-0.14	-0.05	-0.18	
Venezuela	-0.02	-0.11	0.13	0.17

August 1, 1997 to October 31, 1997				
	Chile	Colombia	Mexico	Peru
Colombia	0.12			
Mexico	0.88	0.19		
Peru	0.75	0.17	0.76	
Venezuela	0.03	-0.07	0.08	0.05

September 1, 1997 to November 30, 1997				
	Chile	Colombia	Mexico	Peru
Colombia	0.14			
Mexico	0.78	0.21		
Peru	0.59	0.23	0.70	
Venezuela	0.02	-0.27	0.00	0.13

October 1, 1997 to December 31, 1997				
	Chile	Colombia	Mexico	Peru
Colombia	0.29			
Mexico	0.68	0.41		
Peru	0.56	0.36	0.73	
Venezuela	0.07	0.09	-0.04	0.13

July 1, 1998 to September 31, 1998				
	Chile	Colombia	Mexico	Peru
Colombia	-0.06			
Mexico	0.45	0.01		
Peru	0.27	-0.12	0.62	
Venezuela	0.20	-0.03	0.18	0.08

August 1, 1998 to October 31, 1998				
	Chile	Colombia	Mexico	Peru
Colombia	0.06			
Mexico	0.56	0.00		
Peru	0.35	-0.15	0.61	
Venezuela	0.16	-0.02	0.22	0.08

Table 2.7

The rolling three-month correlation coefficients exhibit contagion effects for the pairs Chile vs. Mexico and Mexico vs. Peru. Especially, after the Hong Kong SAR collapse there is higher co-movement in the exchange rates that continue until the end of 1998. However, the country pairs Brazil vs. Colombia and Peru vs. Venezuela do not exhibit contagion behaviour. This may in fact be due to the reason mentioned above that these countries expect for Peru, exhibited higher forms of government intervention during times of crises rather than portraying market determined values.

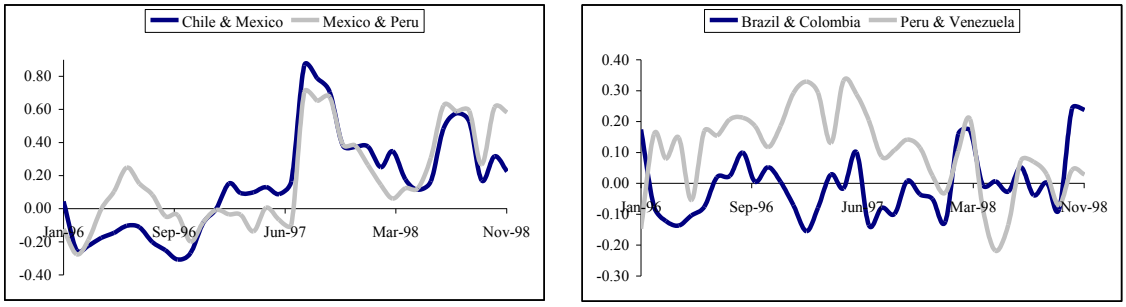
Chile & Mexico
Mexico & Peru
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
Jan-96
Sep-96
Jun-97
Mar-98
Nov-98
Brazil & Colombia
Peru & Venezuela
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
Jan-96
Sep-96
Jun-97
Mar-98
Nov-98

Figure 2.3

TESTING FOR SIGNIFICANT INCREASE IN CORRELATIONS

While studying the full sample and the rolling correlation coefficient panels helps to identify the patterns of correlation during the crisis period, it does not prove that these values are significantly different from market behaviour in tranquil times. Contagion results in the co-movement of markets beyond the fundamentals that explain the historical pair-wise relationships. Therefore, performing a statistical test between the correlation coefficients inherent to the tranquil and the crisis period is necessary to extract the impact of contagion on financial markets in Latin America.

Since the traditional reliance on normal-theory fails in this application of correlation coefficients one can use the non-parametric bootstrap method, which does not require assumptions about the underlying distribution of the data. With the use of bootstrap one can then generate distributions for the correlation coefficients and use the histogram plots to view the resulting distributions for the crisis and tranquil periods. The percentiles for the confidence interval of interest will be studied, and if the interval for the crisis period is disjoint from the confidence interval for the tranquil period at a significant level, then we have tested for the shift in the pair-wise correlation coefficients. This result may lay the basis for supporting the possible existence of contagion in Latin America during financial crises.

The final statistical approach that will be employed by this thesis in understanding the existence of contagion in emerging markets is the principal component analysis (PCA), which is in short a technique to find the directions in which a cloud of data points is stretched most. The three-month rolling panels of correlation coefficients described in the previous chapter will be studied in more detail using the PCA. The aim is to visualise the evolution of the pair-wise coefficients throughout the three-year study period and observe if during the last 18-monhts, referred to as the crisis period, there exists higher variability among the coefficients.

3.1 Non-Parametric Bootstrap Tests

After running the bootstrap on the emerging market bond indices, the stock market indices, and exchange rates for the tranquil and the crisis period, the BC_a confidence intervals are generated. In tables 4.1, 4.2, and 4.3, the pair-wise correlation coefficients that are significantly different at 95% confidence interval are given in a tabular form. This means that the 95% interval for the tranquil period is disjoint from the crisis period 95% correlation coefficient confidence interval. In appendix B, the plots generated by the bootstrap method for the country pairs that exhibit disjoint behaviour are displayed.

The highest number of disjoint pairs is found to be in the stock market data, which is the data set that reflects investor behaviour in the most efficient way since it involves the least amount of control on behalf of the government. The Emerging Market Bond Index is a highly correlated series throughout the analysis period and directly incorporates government-imposed policies on interest rates during times of stress in Latin America. The exchange rates similarly often mirror policies of governments, which try to smooth out sudden and unexpected market behaviour in times of stress.

It is important to note that Argentina and Brazil face large private capital flows by international investors, which get reflected in the results of the bootstrap method. Both the stock market index

and the emerging market bond index for these countries are disjoint. The results are more evident in the stock market data in which the 95% BC_a interval for the tranquil period is 0.37 to 0.55, as compared to levels at 0.70 and 0.82 during crisis period. Again in the stock market results, Mexico, Peru, and Venezuela all have disjoint 95% CI's which confirm the contagion argument.

EMERGING MARKET BOND INDEX 95% CONFIDENCE INTERVAL

	TRANQUIL		CRISIS	
	2.5%	97.5%	2.5%	97.5%
ARGENTINA & BRAZIL	0.76	0.88	0.90	0.95
ARGENTINA & PERU	0.30	0.51	0.63	0.82
BRAZIL & PERU	0.27	0.50	0.63	0.82
MEXICO & PERU	0.29	0.51	0.55	0.78
PERU & VENEZUELA	0.31	0.51	0.53	0.75

Table 3.1

STOCK MARKET INDEX 95 % CONFIDENCE INTERVAL

	TRANQUIL		CRISIS	
	2.5%	97.5%	2.5%	97.5%
ARGENTINA & BRAZIL	0.32	0.52	0.71	0.83
ARGENTINA & CHILE	0.15	0.34	0.44	0.66
ARGENTINA & MEXICO	0.20	0.45	0.63	0.80
ARGENTINA & PERU	0.01	0.18	0.32	0.58
ARGENTINA & VENEZUELA	0.05	0.25	0.25	0.52
BRAZIL & CHILE	0.14	0.34	0.38	0.63
BRAZIL & MEXICO	0.13	0.37	0.60	0.78
BRAZIL & PERU	0.03	0.22	0.30	0.56
BRAZIL & VENEZUELA	-0.07	0.14	0.20	0.48
CHILE & MEXICO	0.11	0.31	0.37	0.63
CHILE & VENEZUELA	-0.04	0.16	0.25	0.55
MEXICO & PERU	-0.01	0.19	0.36	0.62
MEXICO & VENEZUELA	-0.10	0.12	0.20	0.47
PERU & VENEZUELA	-0.10	0.12	0.23	0.47
PERU & RUSSIA	-0.14	0.07	0.09	0.40

Table 3.2

The exchange rate data does not reflect disjoint correlation behaviour, because Argentine peso has successfully maintained its peg to the US$ throughout both the Asian and the Russian crises. Within the exchange rates, countries with most flexible exchange rates confirm the contagion hypothesis with disjoint results. These are Mexico, Chile, and Peru. For Chile and Mexico results show that there is negative or almost no co-movement among the data during the full sample tranquil period, whereas the crisis period posts a 95% CI at 0.29 to 0.61. Similarly, Russia comes into the picture with coefficient intervals at –0.03 to 0.20 with Colombia and 0.10 to 0.42 with Mexico.

EXCHANGE RATE 95% CONFIDENCE INTERVAL

	TRANQUIL		CRISIS	
	2.5%	97.5%	2.5%	97.5%
BRAZIL & MEXICO	-0.15	0.03	0.03	0.29
CHILE & MEXICO	-0.23	-0.03	0.30	0.55
CHILE & PERU	-0.12	0.09	0.17	0.42
MEXICO & PERU	-0.20	0.07	0.37	0.63
COLOMBIA & RUSSIA	-0.21	-0.04	0.00	0.25

Table 3.3

3.2 Principal Component Analysis

The results of the principal component analysis on the stock market indices and the exchange rate data are very promising for supporting the existence of contagion in Latin America during the Asian and the Russian crises. The plot for the loadings of the first principal component confirms the higher variability in correlation coefficients during crises.

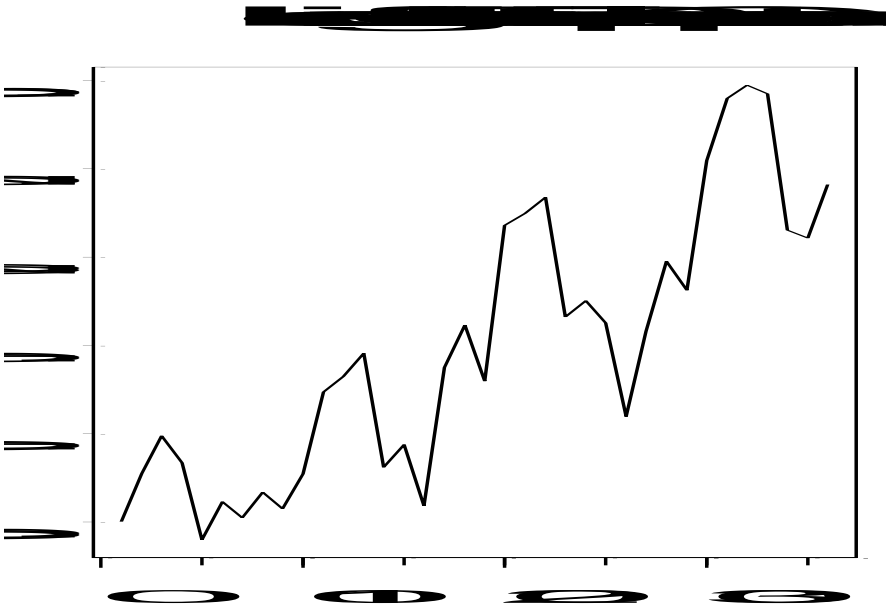

Figure 3.1

Above is the result obtained from the study of stock market indices. The rolling correlation windows are represented by the x-axis. Altogether there are 36 of these three-month rolling panels of which the first 18 represents the tranquil period and the last 18 represents the crisis period. The y-axis represents the relative importance, the loadings, of the months during the three-year study period. The results confirm that starting with the 19th month there is higher variability in the pair-wise correlation data that continues for four months. This period represents the peak of the Asian crisis and the big hit in Latin American stock market after the Hong Kong SAR and Dow Jones collapse. As presented in the introduction, the first few months of 1998 have witnessed the calming down of markets, but levels are still above the tranquil period. The Russian experience falls into the 31st month, which represents the highest variance in the data. It is an interesting comparison to make between the impacts of the Asian crisis and the Russian crisis on the Latin American stock market indices. Russian crisis seems to carry with it higher investor aversion from risk leading bigger falls in the indices. It seems that the financial effects, outlined in the second chapter, play a more important role in Latin American stock markets since the data is a direct representation of private capital flows. After the ruble devaluation, investors chose safe haven investments causing stock market indices to fall in various parts of the world.

Below is the screeplot generated by the principal component analysis on the stock market data. Although the first six components are able to explain 90% of the variability in the data, the only relevant information is hidden in the first component, which as seen in the screeplot represents

53.8% of the variability in the data. The second component only represents 15% more, however, the plots for the loadings of this component do not reveal any relevant information.

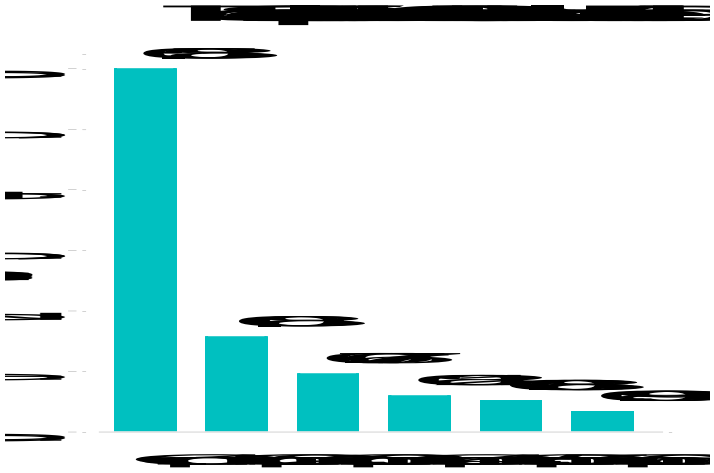

Figure 3.2

The results for the exchange rate data have a similar nature to the stock market data. The plot for the loadings of the first components portrays low variability during the tranquil period with two peak at the heights of the Asian and Russian crisis. For the exchange rate data, Argentina is taken out of the analysis. As mentioned earlier, Argentina has been successful in maintaining its peg, therefore has not portrayed a shift in variability in daily changes.

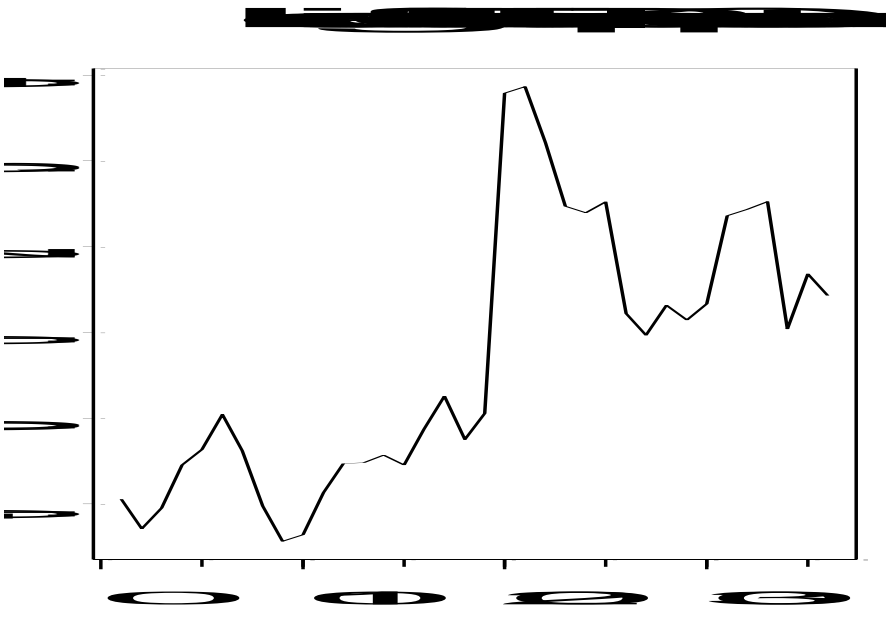

Figure 3.3

Above is the result of the plot for the loadings of the first component. Again the interesting phenomena incorporated in this plot is that the loading of the Asian crisis are higher than the Russian crisis. With the devaluation of the baht there have been a wave of currency crises starting in Southeast Asia and which have carried over to many emerging markets in the world. This plot is representative of the speculative affects especially by the so called "hedge funds" on currencies in Latin America due to international effects. The higher variability in coefficients during this period as compared to the Russian crisis may be representative of the different causes for contagion during the two crises periods. While the Asian crisis has given way to "real" effects of contagion, the Russian crisis has presented reasons, which are explained better by the "financial" effects.

The last figure is the screeplot for the exchange rate data. Although, the first component significantly does worse in explaining the variability in the data in comparison to the stock market data, it still incorporates most of the information relevant in making the study of the principal component analysis.

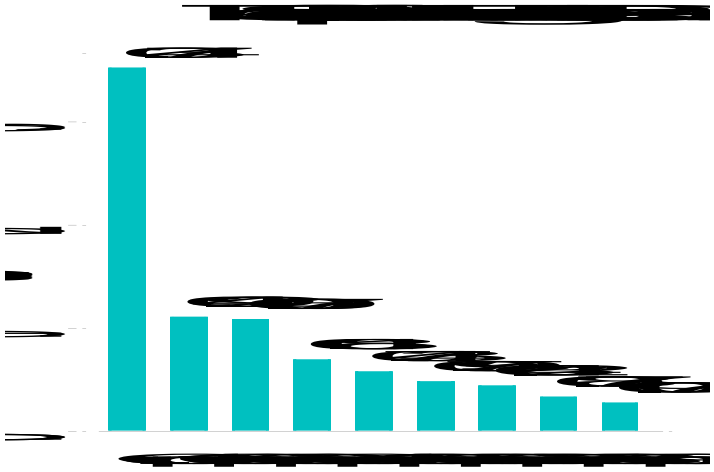

Figure 3.4

[1] International Monetary Fund, 1997b , *World Economic Outlook, Interim Assessment, December 1997: A Survey by the Staff of the International Monetary Fund*, World Economic and Financial Surveys (Washington).

[2] World Economic Outlook, December 1997: A Survey by the Staff of the International Monetary Fund, p. 48

[3] Introducing the Emerging Market Bond Index, Market Brief, July 12, 1995 page 1 J.P. Morgan Securities Inc. Emerging Markets Research

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