Contagion of International Financial Crises: The case of Mexico.*

Santiago Bazdresch
sbazdres@banxico.org.mx

Alejandro M. Werner
awerner@banxico.org.mx

Banco de México
Dirección General de Investigación Económica
5 de Mayo # 18, México D.F., 06059
México

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Abstract

In this paper we study the contagion suffered by Mexico's national markets during the crises in Asia, Russia and Brazil, in the 1997-1999 period. We assess the amount of contagion to Mexico's financial markets using different statistical methods. We then study possible channels of contagion to the Mexican economy and discuss how the economy has dealt with these shocks.

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I. INTRODUCTION

Mexico was the epicenter of the 1994-1995 Tequila crisis in which many of the new features of emerging markets' crises made their appearance. In particular, the issue of whether contagion was present caught the attention of several authors (For example, Valdés (1997), Sachs, Tornell and Velasco (1995) and Calvo and Reinhart (1996)). Since then, the Asian, Russian and Brazilian crises have motivated numerous papers that suggest that writing about contagion might also be contagious.

Fortunately, during the last emerging markets' global crisis Mexico has been at the periphery and has suffered mildly of contagion effects. In this paper, we will focus on how the Mexican economy was affected by the recent emerging markets crises and what was done to minimize its effects.

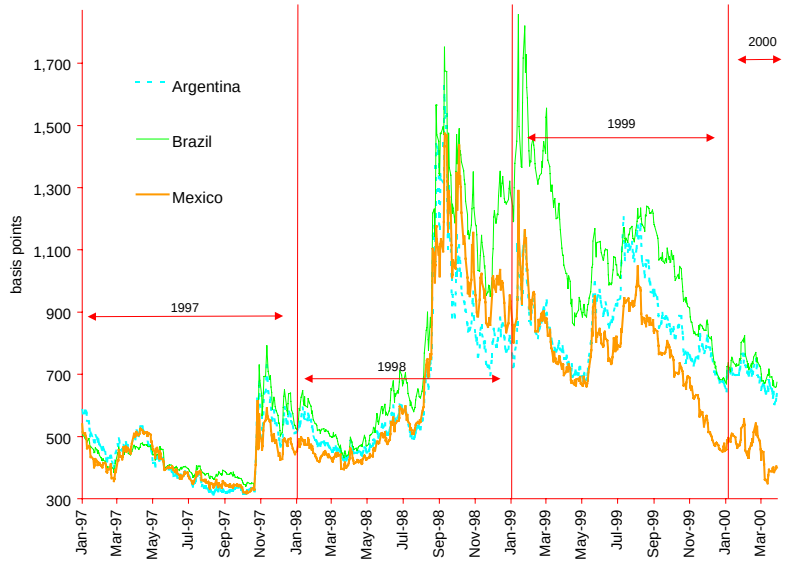
The global financial crisis affected Latin American economies mainly through two channels. First, the collapse of output in the Asian economies impacted world commodity prices, undermining export income and public finances in Latin American countries. In addition, those Latin American economies that maintain close commercial ties with Asia or compete with Asian exports in third markets, were negatively affected by the fall in Asian demand and the depreciation of Asian currencies. In the case of Mexico, during 1998 the economy experienced an important deterioration in its terms of trade (5.5%), due mainly to the fall in the price of oil. Secondly, the volatility in international financial markets caused a reduction in the supply of foreign funds to the region, triggering currency movements and interest rates and generating an important adjustment in domestic absorption.

Although the trade channel was the first vehicle for the contagion of the Asian crisis to Latin America, the financial channel was by far the most important. In particular, the collapse of the Russian economy, and the unilateral moratorium declared on its internal and external obligations, turned out to be very harmful for international financial markets. The most serious consequence was that these phenomena induced an important qualitative change in the way in which emerging markets' sovereign risk is evaluated by market participants. By not extending an effective institutional support to Russia, the false sense of security that had existed with respect to investments in emerging market economies was broken, leading to a substantial reassessment of the

probability of default in other emerging markets. This situation caused institutional investors to reassess the composition of their portfolios, leading to a divestment process away from emerging markets to developed economies.

The general perception in the market that the situation in Brazil was unsustainable magnified the contagion from the Russian crisis to Latin America. Therefore, the process of unwinding Brazilian positions and meeting margin calls led to an intensification of contagion to other countries in the region. The expected nature of the Brazilian devaluation made its effects on third parties present before the event took place. Therefore, when the devaluation occurred on January 13th, its impact on financial markets was smaller than it was originally feared.

FIGURE 1
SOVEREIGN DEBT SPREADS IN LATIN AMERICA



The adverse external environment prompted several Latin American governments to tighten their fiscal and monetary policies. For example, the Mexican government faced this external environment taking an attitude of extreme caution, given the volatility of investor expectations. One of the lessons from the crisis back in 1994-95 was that, once markets overreact, policy has to overreact as well to restore confidence. Following this prescription, the response of monetary and fiscal policies was built on the assumption that the alluded shocks would be permanent, although, as was observed later one, there were elements to justify that they represented temporary phenomena.

Despite the crisis, the Mexican economy displayed a favorable behavior in 1998, even more so if it is compared to that of other economies, both developed and emerging. This has been the result of an adequate policy response and of the large integration with the U. S. economy that has taken place during the last decade.

The rest of the paper is structured as follows: in section 2 we asses the degree of contagion of the Asian, Russian and Brazilian crises to the Mexican economy. In section 3, we discuss the possible channels of transmission of these crises and the policy response implemented by the authorities. Finally, in the last section we present some conclusions.

II. MEASURING CONTAGION

In this section we use different statistical methods to quantify the contagion suffered by Mexico's financial markets because of the international financial crisis that took place in the 1997-1999 period. For this purpose, we follow the work of Baig and Goldfajn (1999) and Rigobon (1999). First, we use simple correlations and Vector autorregresions (VAR's) to measure the degree of co-movement between different Mexican markets and their corresponding ones in the crises countries. We also test whether these correlations exhibited a significant increase during the crises periods using various tests: the two sample heteroscedastic t-test developed by Forbes and Rigobon (1999), Hamilton's regime switching regressions, and finally, we use the specification test developed by Rigobon (1999). Correlations, by their contemporaneous nature, are a very intuitive measure, representing exactly what one imagines when thinking about this topic. In addition to the information contained in correlations, VAR's provide for lagged responses between variables, measure the span of time that shocks take to disappear and provide a first approximation at addressing the issue of causation. Finally, the three statistical tests on the correlation estimates provide more solid arguments for accepting or rejecting contagion.

Our general estimation period ranges from January, 1st 1996 to June 10th, 1999. The year of 1996 represents a good control period, since markets had already recovered from the 1994-1995 crisis and no other crisis had developed yet. In our tests, the Asian crisis starts on July 2, 1997, the date of the Baht's devaluation; the Russian crisis to

begins on August 17, 1998, the day of the Russian payment default; and the Brazilian crisis starts on January 13, 1999, when the real initiated its transition to a floating exchange rate regime. For the estimation of the VAR's we distinguish between the different Asian countries, in which case we take the Malaysian crisis starting on July 14, 1997; the crisis in Indonesia starting on August 14, 1997; the Korean crisis starting on November 6th, 1997, and the Philippine crisis to have begun on July 11th, 1997. We also use Singapore, and take the crisis there starting on the 12th of July of that same year. Finally, to disentangle the Asian crisis further, we consider a second wave that begins with the attack on the Hong Kong stock market and the Hong Kong dollar towards the end of 1997. Following this event, in the last months of 1997 the stock markets and currencies of the Asian 5 as well as Japan suffered a second downturn, the Korean Won and the Japanese Yen depreciated 40% and 10% respectively, from October to December 1997. Indonesia suffered greatly, Korea filed for IMF support and the Hong Kong Hang-Seng stock market plunged. These events are named in this document the "second wave" of the Asian crisis. From the stand point of other emerging markets, it was after these events that there was a substantial change in the world's perception of the Asian crisis as a dangerous situation and contagion around the world was most widespread. During this time, Brazil's and Russia's pegged exchange rate regimes were attacked by investors, in view of continuing imbalances in both countries, considered unsustainable by market participants, although both of these regimes managed to survive for a while longer.

To measure contagion in different markets we use the following information. For stock markets we use the daily closing prices of the nations leading markets, the Bovespa index for Brazil, the KOSPI for Korea, the JCI for Indonesia, the KLCI for Malaysia, the IPC for Mexico, PCOMP for the Philippines, the ASPMT for Russia, the STI for Singapore, and the SET for Thailand. For sovereign spreads we use the EMBI data where available, and construct them as in Baig and Goldfajn (1999) otherwise. Exchange rates are taken as units of the domestic currency per dollar.

a) Market correlation and correlation increase significance tests

The most intuitive measure of contagion is the increase in correlation between Mexico's markets and those of other countries. Therefore, we classify as contagion those correlation coefficient increases that occur with a crisis country, during this country's crisis period.

With this purpose, for each crisis, we build correlation estimates during four different time intervals with the intention of showing a relatively complete picture of events. A very short run interval, from two days before a crisis to one week after; an intermediate one, from two weeks before a crisis to three months after it started; a second three month period, starting three months after the crisis began; and finally a six month interval, again, starting two weeks before the crisis. We expect the short run correlation to capture transitory, large comovements across markets, while the intermediate and long run calculations help explain the persistence of correlation increases. Data for our estimates starts some time before the crises are declared, in order to include a time period where, although markets are under attack, and perhaps behaving crisis-like, there is not a general crisis yet. Also, it diminishes the importance of the precise dates used to identify the start of each crisis.

We find strong evidence of contagion in sovereign debt markets and in stock markets after the second wave of the Asian crisis. In the case of exchange rates, contagion is there, but it is not as clear as in the other two cases, and its validity is difficult to asses when considering the exchange regimes prevailing in the crises countries before their devaluations.

Exchange rate market

During a financial crisis, there does seem to exists a different relationship between the Peso and the movement in other nation's currencies. We find some evidence of immediate contagion during the Asian crisis, and more widespread evidence for contagion during the second wave of this crisis. There is also some contagion to the Peso from the Ruble at the beginning of the Russian crisis, and from the Real after its devaluation on January 13, 1999. The significance of these results is somewhat questionable because most exchange rates were in a pegged or fixed regime before the crisis. Correlation coefficients provide evidence that international financial crises have

increased Mexico's markets' correlation with other emerging markets, as well as limited evidence of contagion from the crisis countries towards Mexico.

We use the two sample heteroscedastic t-test for the purpose of measuring correlation increases, reporting any 1% (***), 5% (**) or 10% (*) statistically significant increase in correlation in the crisis period form the tranquil period.

TABLE 1
EXCHANGE RATE CORRELATION COEFFICIENTS FOR DIFFERENT PERIODS

		BRAZIL	RUSSIA	KOREA	INDONESIA	MALAYSIA	PHILIPPINES	SINGAPORE	THAILAND
Tranquil period		0.00	0.04	-0.03	0.03	0.04	-0.01	0.03	-0.01
Asian crisis, first wave	First week	-0.47	-0.52	-0.45	0.41 ***	0.38 **	0.01	-0.13	0.81 ***
	First three months	-0.10	-0.06	0.05 ***	-0.11	-0.10	0.09 ***	-0.10	0.18 ***
	Second three months	0.16 ***	0.01	0.12 ***	0.16 ***	-0.04	0.01	0.10 ***	-0.04
	First six months	0.12 ***	0.00	0.12 ***	0.14 ***	-0.05	0.02 ***	0.06 ***	0.02 ***
Asian crisis, second wave	First week	-0.13	0.32 **	0.04	-0.46	-0.32	-0.66	-0.79	-0.48
	First three months	0.26 ***	-0.12	0.13 ***	0.21 ***	0.02	0.04 ***	0.14 ***	0.15 ***
	Second three months	0.22 ***	0.00	0.34 ***	0.02	0.19 ***	-0.01	0.19 ***	0.14 ***
	First six months	0.25 ***	-0.09	0.15 ***	0.15 ***	0.07 ***	0.02 ***	0.16 ***	0.15 ***
Russian crisis	First week	-0.09	-0.41	0.15	0.37 **	0.29 *	0.15	0.21	-0.14
	First three months	-0.14	0.18 ***	0.20 ***	0.12 ***	0.03	0.11 ***	0.02	0.13 ***
	Second three months	0.13 ***	-0.31	0.10 ***	0.24 ***	0.06	0.16 ***	0.07 **	0.17 ***
	First six months	0.06 ***	0.10 ***	0.17 ***	0.14 ***	0.02	0.12 ***	0.02	0.13 ***
Brazilian crisis	First week	-0.08	-0.52	0.07	0.38 **	0.08	0.31 **	0.53 ***	0.30 **
	First three months	0.15 ***	-0.28	0.11 ***	0.24 ***	0.04	0.14 ***	0.00	0.20 ***
	Second three months	0.16 ***	-0.10	0.01 **	0.33 ***	-0.13	0.23 ***	0.01	0.20 ***
	First six months	0.14 ***	-0.25	0.08 ***	0.26 ***	0.02	0.00	0.00	0.19 ***

In the case of Brazil, we can see a significant correlation coefficient increase throughout the six month period that followed the Real devaluation, although surprisingly for such a large depreciation, the increase in this coefficient is not significant immediately. In the case of Asia we can see an overall correlation increase during the six months after the crisis started in Thailand, from almost uncorrelated markets during the tranquil period, particularly in the case of Indonesia and Korea. Nonetheless, it is in the second wave of the Asian crisis that we have the most contagion from these countries. Again, these correlation coefficient increases take some time to appear, and first week correlation coefficients are negative. There is also contagion from Russia, although it disappears quickly.

The second wave of the Asian crisis as well as the Russian crisis led to an overall immediate increase in volatility. It is clear that substantial contagion to our country from the Asian crisis materialized only after the events of the fourth quarter 1997, probably reflecting a deep change in beliefs about economies of emerging markets. We find correlation coefficients as high as 0.26 with Brazil (still with the currency band), 0.32 with Russia, 0.21 with Indonesia, and 0.34 with Korea, all of which were barely different from zero during the tranquil period. It is important to remember that these countries had a pegged exchange rate regime before the crisis occurred, thereby limiting any possible correlation, therefore the increases in correlation might only signal the latent relationship that was obscured by the prevailing exchange rate regimes.

Stock Markets

Stock market correlation increases are a much more widespread phenomenon, specially within regional borders. Throughout our sample, the correlation between Mexico's IPC and Brazil's Bovespa does not go below 0.27. The Asian crisis lead to a sizable increase in correlation of the Mexican stock market with those of the crisis countries, particularly during the "second wave" of this crisis. Correlation with all Asian countries increases during these months, from –0.04 to 0.21 with Korea, from 0.04 to 0.39 with the Philippines and from 0.03 to 0.40 with Singapore. This relationship between the Asian and the Mexican stock markets is the most outstanding case of contagion from the correlation point of view. On the other hand, during the Russian crisis thre is also an increase in the Mexican stock markets' correlation with the Russian one since this correlation is significantly greater than the one observed in the tranquil period, nevertheless, this phenomenon appeared since the onset of the Asian crisis. If compared with the tranquil period, the Brazilian crisis does lead to an increase in correlation of the IPC index with the BOVESPA index, although this correlation is not as high as during the crisis in Russia.

TABLE 2
STOCK MARKET CORRELATION COEFFICIENTS FOR DIFFERENT PERIODS

		BRAZIL	RUSSIA	KOREA	INDONESIA	MALAYSIA	PHILIPPINES	SINGAPORE	THAILAND
Tranquil period		0.27	-0.03	-0.01	0.23	0.14	0.11	0.17	0.13
Asian crisis, first wave	First week	0.35	-0.25	-0.28	-0.20	-0.15	0.24	0.46 **	-0.27
	First three months	0.47 ***	0.30 ***	-0.02	0.31 ***	0.09	0.21 ***	0.28 ***	0.07
	Second three months	0.79 ***	0.08 ***	0.18 ***	-0.03	-0.01	-0.11	0.01	-0.15
	First six months	0.68 ***	0.12 ***	0.17 ***	0.04	0.02	-0.01	0.08	-0.05
Asian crisis, second wave	First week	0.54 **	-0.76	-0.56	-0.40	-0.62	-0.54	0.01	-0.62
	First three months	0.65 ***	0.26 ***	0.17 ***	0.25	0.26 ***	0.35 ***	0.37 ***	0.20 ***
	Second three months	0.64 ***	0.33 ***	0.34 ***	0.31 ***	0.39 ***	0.17 ***	0.38 ***	0.39 ***
	First six months	0.65 ***	0.29 ***	0.21 ***	0.26 ***	0.29 ***	0.30 ***	0.36 ***	0.26 ***
Russian crisis	First week	0.80 ***	-0.22	-0.69	0.25	0.12	-0.16	-0.17	0.11
	First three months	0.81 ***	0.13 ***	0.00	-0.03	0.14	0.22 ***	0.25 ***	0.07
	Second three months	0.63 ***	0.24 ***	0.00	0.15	0.05	0.04	0.20 **	0.16 *
	First six months	0.73 ***	0.16 ***	0.00	0.02	0.12	0.17 ***	0.23 ***	0.10
Brazilian crisis	First week	0.85 ***	0.22 *	-0.47	0.27	0.45 **	-0.07	0.59 ***	0.31
	First three months	0.65 ***	0.20 ***	-0.05	0.04	0.05	-0.06	0.26 ***	0.03
	Second three months	0.68 ***	0.10 ***	0.02 *	0.27 ***	-0.03	0.23 ***	-0.14	0.05
	First six months	0.65 ***	0.15 ***	-0.02	0.09	0.01	0.02	0.13	0.02

Correlation of Mexico's stock market with those of other countries, particularly Brazil's, during the Russian crisis is significantly different from tranquil period. Brazil's crisis was most probably anticipated by market participants just after the Russian crisis, leading to a sustained attack against the Real, although Brazil managed to endure the situation for a few more months. This situation led to a high correlation of Mexico's and Brazil's markets after the crisis in Russia. Similarly, it is during the second wave of the Asian crisis that the strongest reaction from market participants is produced, significantly increasing all correlation measures in our sample. The high correlation with Asian markets disappeared after these countries' crises, and, during the crisis episodes of Russia and Brazil it increased in some cases, but it was a transitory phenomenon.

Sovereign debt market

During crises, Mexico's sovereign debt prices were more correlated with those of the crises countries', than during the tranquil period.

TABLE 3
SOVEREIGN DEBT SPREAD CORRELATION COEFFICIENTS FOR DIFFERENT PERIODS

		BRAZIL	RUSSIA	KOREA	INDONESIA	MALAYSIA	PHILIPPINES	THAILAND
Tranquil period		0.66	-0.02	-0.01	0.05	-0.18	0.13	NA
Asian crisis, first wave	First week	0.87 ***	-0.29	-0.52	0.36 **	-0.41	0.73 ***	.
	First three months	0.71 ***	0.06 ***	-0.07	0.01	0.06 ***	0.25 ***	.
	Second three months	0.79 ***	0.06 ***	0.23 ***	0.08 *	0.47 ***	0.62 ***	.
	First six months	0.79 ***	0.07 ***	0.22 ***	0.08 ***	0.25 ***	0.59 ***	.
Asian crisis, second wave	First week	0.91 ***	0.02	0.15	-0.46	0.51 ***	0.88 ***	.
	First three months	0.69 ***	0.13 ***	0.14 ***	0.02	0.02 ***	0.46 ***	.
	Second three months	0.85 ***	0.23 ***	0.05 ***	0.47 ***	0.33 ***	0.53 ***	.
	First six months	0.76 ***	0.17 ***	0.11 ***	0.17 ***	0.04 ***	0.48 ***	.
Russian crisis	First week	0.50	-0.14	0.00	-0.05	-0.07	0.26	.
	First three months	0.82 ***	0.17 ***	0.20 ***	0.21 ***	-0.01 ***	0.57 ***	.
	Second three months	0.82 ***	0.20 ***	0.50 ***	0.27 ***	0.17 ***	0.60 ***	.
	First six months	0.81 ***	0.18 ***	0.26 ***	0.20 ***	0.02 ***	0.57 ***	.
Brazilian crisis	First week	0.72	0.25 **	0.76 ***	-0.35	-0.46	0.17	.
	First three months	0.83 ***	0.33 ***	0.56 ***	0.25 ***	0.14 ***	0.59 ***	.
	Second three months	1.00 ***	0.98 ***	0.99 ***	0.98 ***	0.99 ***	0.99 ***	.
	First six months	0.98 ***	0.94 ***	0.95 ***	0.93 ***	0.94 ***	0.96 ***	.

During the first three months of the Asian crisis, correlation of Mexican debt with that of the Asian countries had a general increase. The second wave of the Asian crisis and the Russian payment default and the devaluation of the Ruble lead to the most thorough increases in these sovereign spread correlation coefficients. Correlation with Brazil does not increase any more after this country's crisis, which is evidence of the anticipation of this crisis long before it happened and, therefore, its effect on the Mexican market appeared beforehand.

b) VAR Analysis

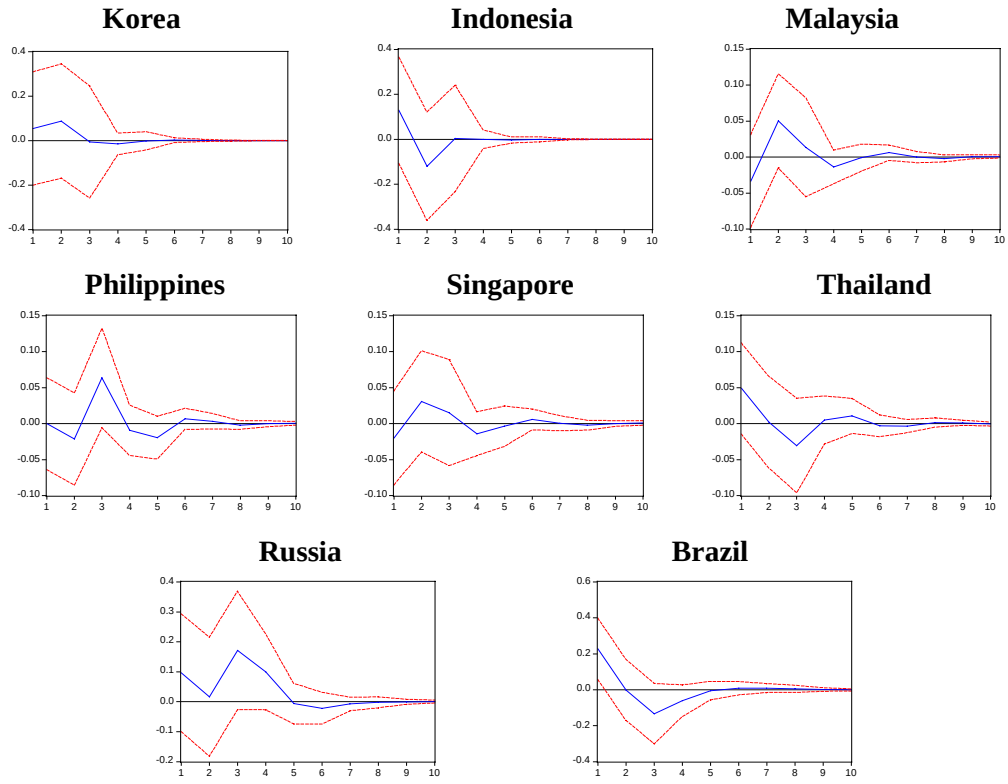
VAR analysis has some advantages over simple correlation coefficients. It considers lagged as well as contemporary effects of one country's markets over another and it is also useful to quantify the size and significance of one market's influence over the other. For each country, we use daily data spanning three months; beginning two weeks before the day that country's crisis started. This time span lets us compute if there are any long lasting effects, and if strong relationships between countries markets do not disappear within one or two days of the start of a crisis.

We find strong effects on Mexican markets from the Brazilian devaluation in the case of exchange rates, from Brazil and some Asian countries in the case of stock markets and from Russia, Brazil and most Asian countries in the case of sovereign debt spreads.

Exchange Rate

The exchange rate was not directly affected by movements in other countries' currencies, except for Brazil's Real.

FIGURE 2
RESPONSE OF MEXICO'S EXCHANGE RATE TO A ONE STANDARD DEVIATION INNOVATION IN EACH COUNTRY'S EXCHANGE RATE, DURING EACH COUNTRY'S CRISIS.

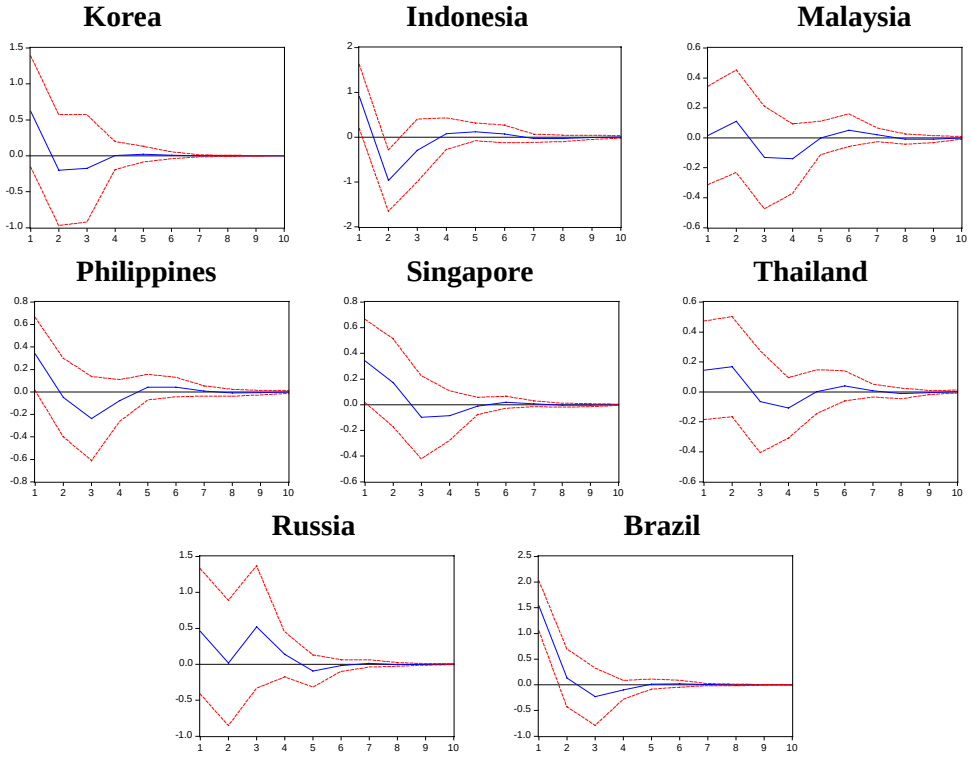


The exchange rate was not directly affected by any movement in the price of the Asian currencies during the Asian crisis, most of the effects form these countries have the right sign, but are not significant. Its response to the Russian Ruble movements, during the Russian crisis, is not significant at any point in time either. On the other hand there is a statistically significant response of the exchange rate when there is a movement in Brazil's Real/Dollar exchange rate. As in the case of the correlation analysis, currency markets do not appear to be very susceptible to crisis contagion, particularly beyond regional borders.

Stock markets

In the case of stock markets, we find that during the Asian crisis the effects of movements in the Asian markets did not lead to very significant changes in the Mexican stock market. Korea, Malaysia, and Thailand have no significant effect at all, and the rest have barely significant ones. The response to a shock in Indonesia has a greater magnitude, although it is barely significant as well.

FIGURE 3
RESPONSE OF MEXICO'S STOCK MARKET TO A ONE STANDARD DEVIATION INNOVATION IN EACH COUNTRY'S LEADING STOCK MARKET, DURING EACH COUNTRY'S CRISIS.

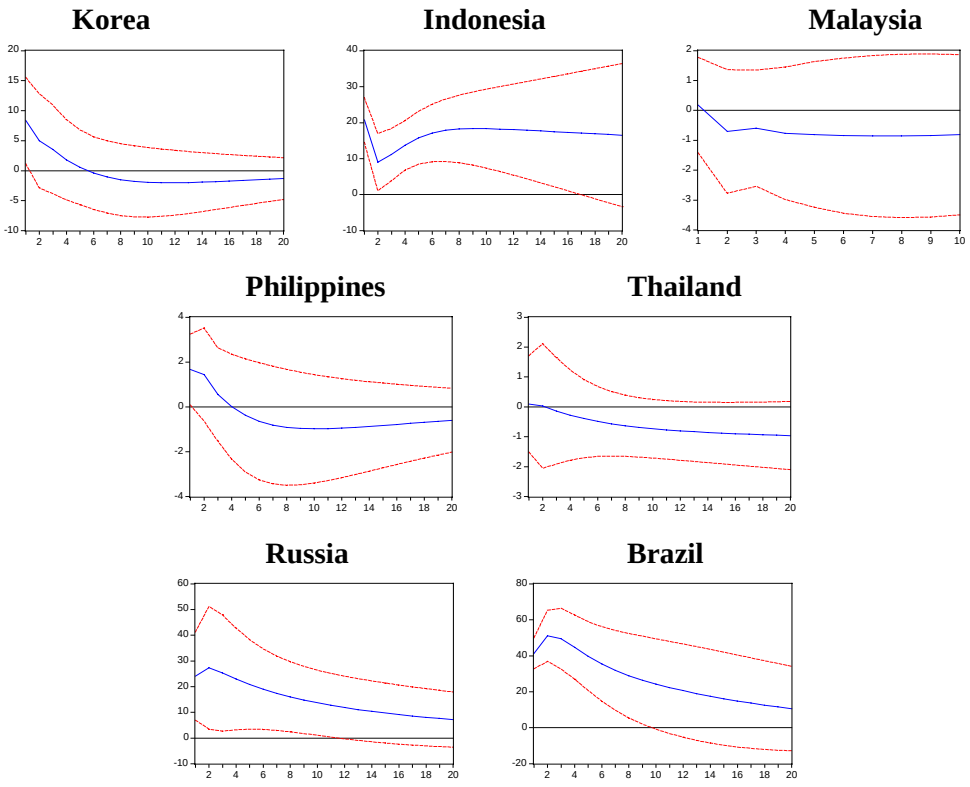


The response to the Russian market's movements is similar. On the other hand, during the Brazilian crisis this country's stock market had some influence on the Mexican stock market. The reactions were in the right direction, they were statistically significant, and even more, the magnitude of the reaction is large. Although it is not clear if this movement is particular to crisis periods it is clear that any significant movement in the Brazilian stock market was felt in Mexico's markets.

Sovereign debt market

Sovereign spread VAR's are constructed using the variables in levels rather than in differences because unit root tests indicated that these series are stationary.

FIGURE 4
RESPONSE OF MEXICO'S SOVEREIGN SPREAD TO A ONE STANDARD DEVIATION INNOVATION IN CRISIS COUNTRIES' SOVEREIGN SPREAD, DURING THEIR CORRESPONDING CRISIS



The effect of Asian countries sovereign spread innovations on Mexico's was small but long lasting, effects from increases in the sovereign spreads of Philippines, Korea, Indonesia and Thailand are significant at some point, but effects from increases Malaysia's are not so. As in the case of foreign exchange and stock markets, the reactions to Russia and Brazil are much larger. An increase in the Russian sovereign spread lead to a large increase in Mexico's spread lasting several periods. For Brazil, the effect on Mexican debt markets was immediate, significant, and long lasting as well.

VAR analysis summary

Effect on Mexico's markets from crisis countries markets' movements

	Exchange rate	Stock markets	Sovereign spreads
Asian crisis	No significant effects.	Significant effects from Indonesia, Philippines, and Singapore. Large response to Indonesia.	Significant and long lasting effects from some Asian countries.
Russian crisis	No effect.	No effect.	Significant and lasting response.
Brazilian crisis	Small reaction.	Very strong and significant effect of magnitude comparable or even larger than original shock.	Large, significant, and lasting response.

c) Regime switching analysis

In this section, we use Hamilton's regime switching regression to find evidence of contagion. We try to explain the behavior of the Mexican markets with that of the crisis countries markets, and expect to find that during tranquil periods the influence of other countries markets' movements on the Mexican market is small or negligible, while it is a useful explanatory variable during crisis times. We expect these two regimes to stick to our perception of tranquil and crisis times to some extent, and to show evidence that during volatile or crisis times, the explanatory variable coefficients are larger than during tranquil times.

We build a regime switching model, where we allow for the coefficients of the explanatory variables and the variance of the estimation error to change from one regime to the other. The estimation technique is to optimize the maximum likelihood function, which assumes a normally distributed error on a model of the form:

$$y_t = \beta_0 + \sum_{i=1}^{n} \beta_i^j x_i + \varepsilon_i^j \qquad (1)$$

where β_i^j depends on the regime, (j= 1,2) and the error ε_t^j is a normally distributed variable with zero mean and standard deviation σ^j also dependant upon the regime.

The estimation procedure also generates ergodic probability and smoothed probability estimates. We build estimates for the three markets considered, one at a time. Russian and Brazilian financial variables are used as the explanatory variables because introducing other countries markets did not provide additional information.

TABLE 4
REGIME SWITCHING ESTIMATION RESULTS

Market		Crisis regime			Tranquil regime			Log-likelihood
		Coefficients	Variance	Ergodic probability	Coefficients	Variance	Ergodic probability	
Exchange rate	Brazil	0.36 (0.22)	0.001 (0.0001)	0.16	0.015 (0.015)	0.00001 (0.000001)	0.84	6622.4
	Russia	0.03 (0.01)			0.019 (0.07)			
Stock market	Brazil	0.39 (0.038)	0.00063 (0.0001)	0.26	0.025 (0.034)	0.0001 (0.00001)	0.74	5236.8 *
	Russia	0.15 (0.025)			0.06 (0.015)			
Sovereign spreads	Brazil	0.68 (0.03)	0.00001 (0.000002)	0.39	-0.005 (0.02)	0.0000005 (0.0000001)	0.61	3438.5 *
	Russia	0.56 (0.08)			-0.29 (1.33)			

Values in parenthesis are estimated standard errors of coefficient above.
* Log-likelihood is significantly larger for switching regime specification than for single coefficient specification at the 10% level.

The results show two clearly identified regimes for each market considered. There exists a low variance, or tranquil regime where the process stays most of the time and where other countries' market results have little influence, and a high variance or crisis regime, where other markets around the world are helpful as explanatory variables, and which does not appear as frequently. For both countries, the increase detected in their coefficient, from tranquil periods to crisis periods, is substantial. We find that the Brazilian Stock market movements only had a coefficient of 0.025 during tranquil times, but a 0.39 coefficient during crisis times to explain the Mexican stock market. For Sovereign debt we find changes in Brazil's coefficient, it is 0.69 during crisis times and 0.005 during tranquil times.

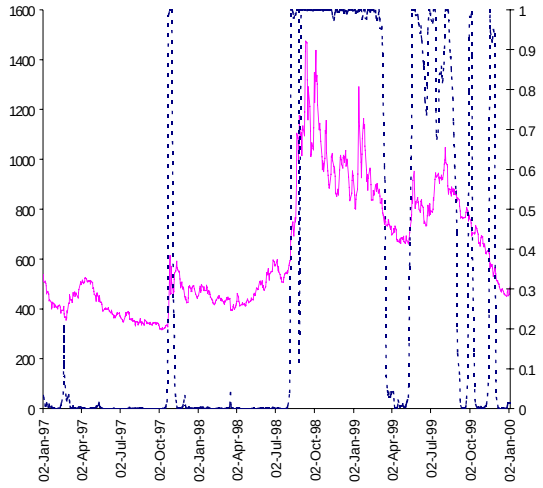
For significance test purposes, we estimate the same model but with constant explanatory variables' coefficients, that is, having the same coefficients β_i^j in equation (1) for both regimes. This leads to significance at the 10% level of the switching regime in both the Sovereign Spread and the Stock Market estimations. From these

estimates, we can conclude that there is some evidence of contagion from the Brazilian and Russian markets to Mexico.

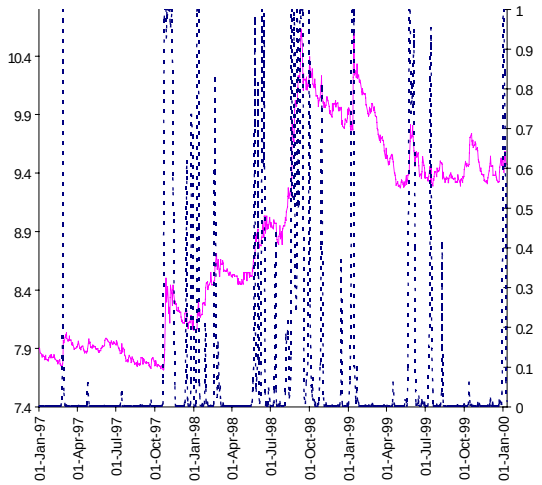
The smoothed probabilities of the estimated switching regime processes show that the crisis periods identified by the model for country risk matches very well the periods of turbulence in international capital markets, while the exchange rate model does not do such a good job at identifying these two different periods.

FIGURE 5

MEXICAN SOVEREIGN SPREAD AND PROBABILITY OF CRISIS REGIME.



EXCHANGE RATE AND PROBABILITY OF CRISIS REGIME.



d) Specification test

Following the work of Rigobon (1999), in this section we use an alternative scheme for proving contagion. The idea is to prove whether the observed increase in covariance between two markets can be attributed to a change in the relationship between them, or it is just the result of increased variance of one of them, within the same framework of inter-market relationships.

With this purpose, we construct two instrumental variable estimators to measure the relationship between the foreign market and the national one, which will be equal under the hypothesis of no structural change. Then we make a significance test to detect id

there exists any difference between these two estimators. This constitutes an overidentification or a Hausmann specification test which allows us to prove whether the transmission of shocks is stable when the variance in one market increases.

The model is the following,

$$y_t = \beta x_t + \varepsilon_t$$
$$x_t = \eta_t,$$

where x represents the foreign market and y represents the national market, and η and ε are stochastic and independent shocks.

Rigobon argues that, as long as the two shocks, η, and ε, are uncorrelated, covariance between the two variables will increase proportionally to the variance of the independent variable *x*, while the variance of the dependent variable will increase less than proportionally. This will turn any independent increase in the variance of *x* into an increase in the correlation coefficient, even in the absence of structural change.

To solve this problem the author proposes building a test using two variance covariance matrices. In a complete model of the following form:

$$y_t = \beta x_t + \gamma z_t + \varepsilon_t$$
$$x_t = \alpha y_t + z_t + \eta_t$$

the difference of the variance covariance matrix of *x* and *y* before (l) and after (h) an increase in the variance of x, $\sigma_\eta^h = (1+\delta)\sigma_\eta^l$, will be equal to:

$$\Delta\Omega_t = \Omega_h - \Omega_l = \frac{\delta\sigma_\eta^2}{(1-\alpha\beta)^2}\begin{pmatrix} \beta^2 & \beta \\ \beta & 1 \end{pmatrix}$$

From here it is clear that we can obtain two independent estimates of β, namely:

$$\hat{\beta}^1 = \frac{COV^h(x,y) - COV^l(x,y)}{VAR^h(x) - VAR^l(x)}$$

$$\hat{\beta}^2 = \frac{VAR^h(y) - VAR^l(y)}{COV^h(x,y) - COV^l(x,y)}$$

or $\Delta\Omega_{12} / \Delta\Omega_{22}$ and $\Delta\Omega_{11} / \Delta\Omega_{12}$, where VAR^h and COV^h are calculated for data during the crisis or high volatility period and VAR^l and COV^l are calculated during the tranquil or low volatility period.

Under the hypothesis of an increase of σ_η^2, these two numbers would be estimates of β, and, under the hypothesis of an increase of σ_ε^2 or of σ_z^2 instead of σ_η^2, these two numbers would be estimates of α or $\frac{\beta+\gamma}{1+\alpha\gamma}$ respectively. In any case, under the hypothesis of an increase of any of these three variances, both of these coefficients should have the same value, assuming no structural change in the model.

The following tables show both of the estimates of β, for the relationship between a Mexican market and a foreign one. Just as in the work of Rigobon, we found significant evidence of a structural change in very few cases. We present the two estimates and, in parenthesis, the estimated standard error of their difference. Following the practice established in the rest of our document, we use longer periods for crisis and tranquil times than those used by Rigobon. We use the year of 1996 as the tranquil period and, for each crisis, we use a three month window after the starting date.

Stock markets

TABLE 5
STOCK MARKET IDENTIFICATION TEST RESULTS

	Brazil		Russia		Corea		Indonesia		Malaysia		Philippines		Singapore		Thailand	
	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2
Asian crisis, first wave	0.24	0.35	-0.68	0.63	0.58	-10.81	0.14	0.46	0.03	2.28	0.14	0.70	0.25	1.49	0.02	3.28
	(6.95)		(66.77)		(10,315.95)		(17.76)		(358.35)		(37.05)		(235.88)		(822.97)	
Asian crisis, second wave	0.77	1.02	0.07	8.78	0.13	2.34	-0.02	-16.17	-0.02	-37.81	-0.16	-13.79	-0.08	-33.51	-0.20	-6.67
	(0.54)		(97.31)		(6.73)		(321.10)		(1,818.24)		(240.97)		(1,523.25)		(56.08)	
Russian crisis	0.62	0.83	0.05	3.54	-0.04	-55.28	-0.10	-7.04	0.08	5.95	0.18	8.60	0.34	6.95	0.01	136.5
	(0.24)		(12.14)		(2,906.45)		(47.03)		(33.50)		(70.10)		(44.71)		(17,800.78)	
Brazilian crisis	0.33	0.54	0.18	2.21	0.06	18.43	0.07	11.17	-0.05	-48.70	-0.01	-358.0	0.65	3.73	0.02	87.26
	(0.64)		(17.83)		(1,292.77)		(465.48)		(9,110.71)		(468,655.59)		(46.38)		(28,891.44)	

Exchange rates

TABLE 6
EXCHANGE RATES IDENTIFICATION TEST RESULTS

	Brazil		Russia		Corea		Indonesia		Malaysia		Philippines		Singapore		Thailand	
	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2
Asian crisis, first wave	-0.81	-0.40	0.27	6.19	0.04	-1.83	-0.02	0.03	-0.06	0.28	0.03	0.36	-0.07	-0.41	0.02	-0.02
	(2,300.51)		(4,006.04)		(1,342.23)		(15.76)		(27.54)		(6.41)		(315.53)		(2.17)	
Asian crisis, second wave	4.73	37.85	-0.11	1323.96	0.02	3.47	0.04	1.70	-0.05	-12.29	0.01	53.73	0.07	61.76	-0.01	-54.41
	(853.30)		(868,471.53)		(5.92)		(1.35)		(76.29)		(1,428.63)		(2,003.30)		(1,469.89)	
Russian crisis	-1.52	-118.10	0.02	0.41	0.25	6.09	0.03	2.17	0.13	8.62	0.09	11.91	0.03	72.15	0.23	7.5
	(12,017.06)		(0.14)*		(31.06)		(4.03)		(62.81)		(118.75)		(4,345.60)		(45.18)	
Brazilian crisis	0.04	1.64	-0.06	-3.00	0.38	10.56	0.12	1.38	-0.21	154.59	0.20	9.2	0.49	30.88	0.58	5.10
	(2.71)		(10.12)		(120.52)		(1.82)		(24,710.21)		(88.88)		(974.09)		(24.75)	

Sovereign spreads

TABLE 7
SOVEREIGN SPREADS IDENTIFICATION TEST RESULTS

	Brazil		Russia		Corea		Indonesia		Malaysia		Philippines		Thailand	
	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2	β^1	β^2
Asian crisis, first wave	1.05	2.12	-0.01	0.14	2.81	9.21	0.04	-78.65	0.56	-6.35	1.32	2.35	-1.61	-6.53
	(5.80)		(0.12)		(735.12)		(23,131.17)		(115.81)		(21.02)		(320.72)	
Asian crisis, second wave	0.82	1.21	0.01	0.75	0.39	3.29	0.37	7.69	-31.28	14.12	1.29	3.37	-0.20	-7.17
	(0.09)*		(0.10)*		(1.71)*		(10.69)		(1,061.51)		(1.30)		(9.72)	
Russian crisis	0.76	1.17	0.01	0.12	0.30	9.78	0.20	3.31	-0.05	-24.34	1.25	3.70	-0.15	-25.8
	(0.01)*		(0.00)*		(3.22)*		(0.33)*		(17.79)		(0.28)*		(21.74)	
Brazilian crisis	0.52	0.80	0.00	-0.29	1.22	6.50	0.44	6.79	0.41	13.94	2.42	7.0	1.62	19.40
	(0.02)*		(0.01)*		(3.14)*		(4.01)		(16.55)		(3.51)		(34.37)	

We find very few coefficient differences significantly different from 0, meaning there is only evidence of contagion in the currency markets in the case of the Russian crisis, and in the second wave of the Asian crisis. There is also evidence of contagion in the sovereign debt market only during the Russian crisis, the Brazilian crisis and the second wave of the Asian crisis, with Korea in particular.

The evidence presented in this section documents the presence of contagion from recent financial crises towards Mexico, since the second wave of the Asian crisis. However, it seems that contagion intensified after the Russian crisis, and that one of the main causes was the association, in investors' minds, of economic developments in Brazil and Mexico.

III. CHANNELS OF TRANSMISSION AND THE POLICY RESPONSE

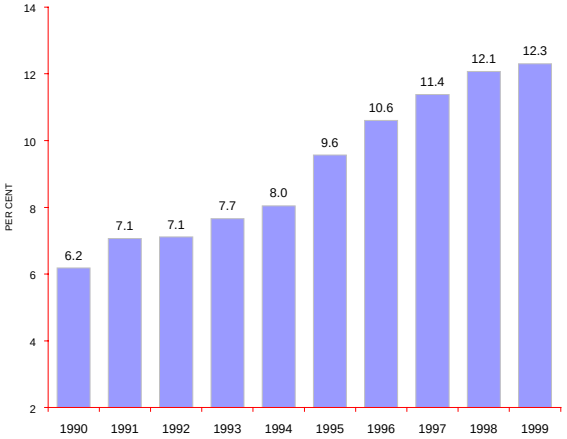
Following Masson (1998) we can think of many reasons why crises can be contemporaneous in time. First, these crises could be due to a common cause, such as an increase in world interest rates or a fall in commodity prices. Another possibility, which has been stressed by Corsetti et al (1998), is that a crisis in one country could deteriorate the economic fundamentals of another country, leading to stressful conditions in this second country. Finally, Masson highlights that a crisis might trigger a crisis elsewhere for reasons unexplained by macroeconomic fundamentals, perhaps because it leads to shifts in "market sentiment." This last type of episode is described by Masson as true contagion. Technically, Masson associates this "true contagion" with a situation of an economy subject to multiple equilibria where the news of a crisis elsewhere triggers a move from the stable and "good" equilibrium to the crisis or "bad" equilibrium.

As we mentioned in the introduction, the Asian crisis first affected Latin American economies through its impact on commodity's prices, undermining exports and public finances in the region. In addition, those nations that maintain close commercial ties with Asia or compete with Asian exports in third markets, were negatively affected by the fall in Asian demand and the depreciation of Asian currencies. In the case of Mexico, the economy experienced an important deterioration in its terms of trade during 1998 of 5.5%, due mainly to the fall in the price of oil. At the beginning of the crisis it was thought that, although the share of Mexican trade with the crises countries was extremely small, the indirect links with the Asian countries, through competition of Mexican exports in the U.S. market, was not negligible. In 1998, a study conducted by Banco de Mexico concluded that there might be intense competition from Asian products in U.S. markets in those lines of production where Mexican exports represented less than 10% of total U.S. imports. However, in those "items" where Mexican exports were larger than 10% of U.S. total imports, the competition from Asian countries was low or moderate[1]. To asses, ex-post, the degree of substitution, we looked at each of 1250 items imported by the U.S., if the share of Mexican and other non Asian exports in U. S. imports for a given product decreased and, obviously, the share of Asian countries' exports increased, it was considered that substitution took

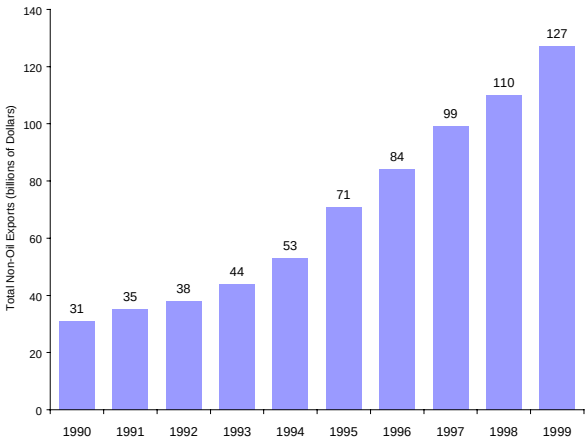
place. This calculation turned out that, during 1998, 1.3 billion dollars of Mexican exports (1.1% of total exports) were displaced by Asian exports. Notwithstanding this phenomenon, Mexico was able to raise its share in U.S. total imports through increases in other exports. Therefore, the contagion through this channel was small.

FIGURE 5

MEXICAN EXPORTS TO THE U.S. AS A PERCENTAGE OF TOTAL U.S. IMPORTS



TOTAL NON-OIL MEXICAN EXPORTS



Although the impact on the external accounts was negligible, the drop in the price of oil affected public revenues significantly, given that 36.4% of government revenues came from oil during 1997. Therefore, in this case, the crisis in Asia, through its impact on the price of oil did affect fundamentals in Mexico. The total loss of public revenues summed up to 1.3% of GDP.

Fiscal policy reacted immediately to the loss of fiscal revenues derived from the fall in the price of oil (from a budgeted level of 15.5 dpb to a level of 10.16 dpb). During 1998, three adjustments to the budget were implemented and an important effort was carried out to increase tax compliance. These measures completely compensated the fall in public revenues, and made it possible to reach a deficit of 1.24% of GDP, slightly below the one programmed at the beginning of the year. It must be pointed out that this fiscal effort was made after the fiscal measures undertaken in the last four years to finance the costs associated with the reform of the pensions system, as well as the diverse programs oriented towards restructuring the financial system. The fiscal adjustment turned out to be very important, given that during the second half of 1998

[1] See The Mexican Economy for 1998 and 1999 by Banco de México.

international financing collapsed, therefore it could have been extremely costly to finance a larger public sector deficit.

The fiscal response and the negligible impact of the Asian crisis on Mexico's external accounts minimized the effects of the crisis on the Mexican economy. However, during august, the collapse of the Russian ruble and the following debt default by that country had serious consequences on emerging market countries due to the following reasons:

a) Since significant amounts of resources from investment funds were trapped in Russia, these funds were pushed to liquidate their positions in other liquid markets, such as Mexico,

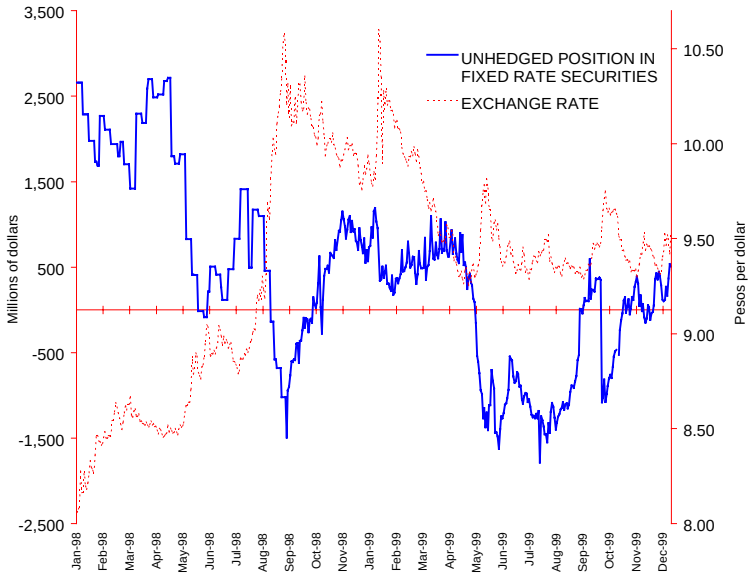
b) in the absence of a coordinated support from the International Monetary Fund and the G-7 countries to Russia the false sense of security based on the notion that some countries were "too large to fail" evaporated, leading to an important reassessment of emerging market risk generating important refinancing problems in these markets, and

c) due to this change in the assessment of emerging market risk, investors began to anticipate the devaluation of the Brazilian currency. Under the assumption that the peso was highly correlated with the fortune of the Brazilian real, peso futures became a useful venue to hedge Brazilian risk. Therefore, the peso exchange rate was indeed affected, since Mexican banking institutions, the counterpart of the aforementioned hedging transaction, balanced their positions by purchasing dollars against pesos in the spot market.[2]

The following graph clearly shows the inverse relationship between the unhedged exchange rate risk position in fixed-rate securities held by foreigners and the value of the peso.

[2] This issue is also analyzed in Kodres and Pritsker (1998), and Jochum and Kodres (1998).

FIGURE 6
UNHEDGED POSITION IN FIXED RATE SECURITIES
AND THE PESO/DOLLAR EXCHANGE RATE

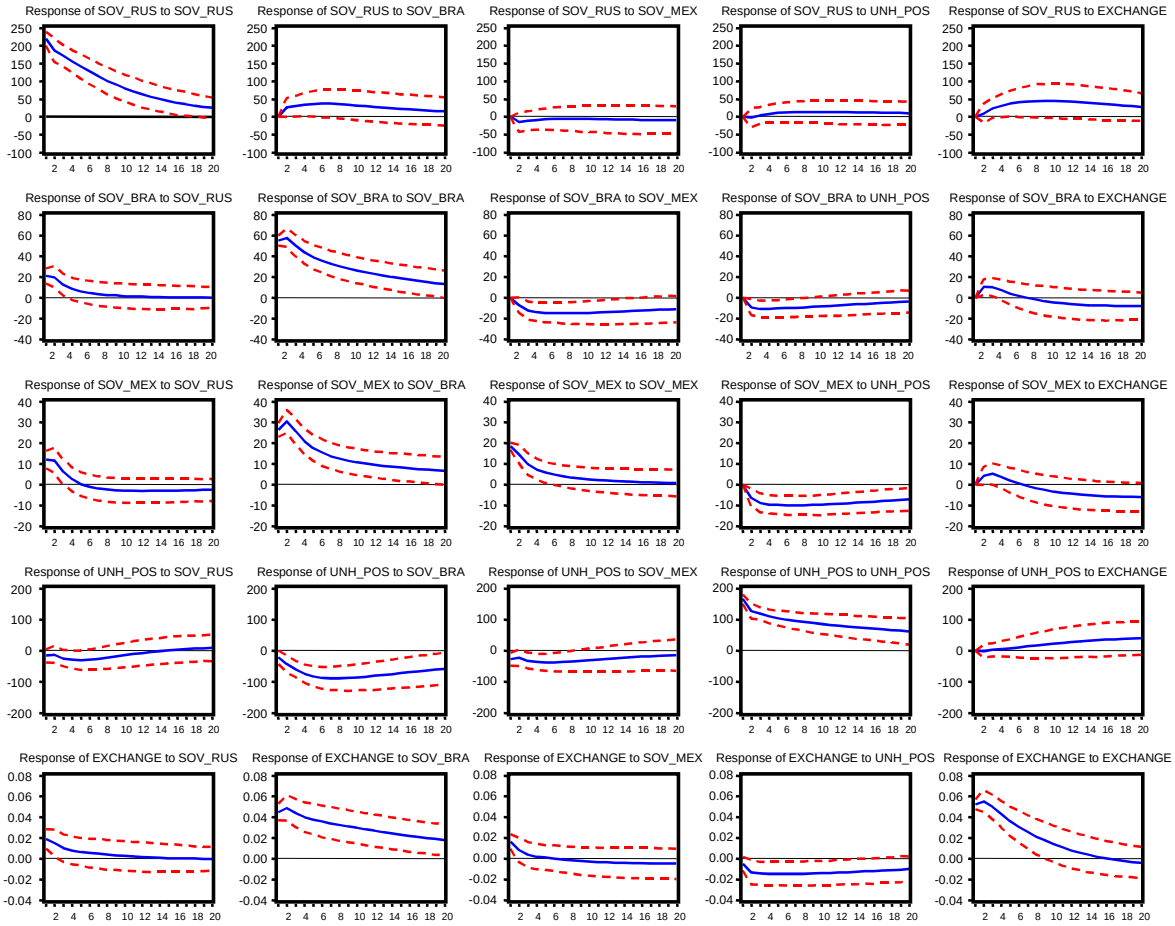


When the unhedged position becomes negative, that means that overseas investors are selling pesos in the derivative futures markets for amounts above their holdings of peso-denominated securities. To validate this chain of events we ran a VAR with daily data spanning one year, two weeks before the Russian devaluation[3] where we include Russian sovereign spreads (SOV_RUS), Brazilian sovereign spreads (SOV_BRA), the Mexican sovereign spreads (SOV_MEX), the unhedged peso position held by foreigners (UNH_POS) and the peso/dollar exchange rate (EXCHANGE). The impulse response functions, presented in figure 7, justify the channel of contagion described previously. Shocks to Russian country risk did not affect Brazilian and Mexican country risk. However, a direct shock to Brazil had a strong impact on Mexico's spreads, on sales of peso futures, and generated a depreciation of the currency. From the VAR it is clear that Mexico's variables respond mainly to the shock from Brazil, and not to the shock on Russia.

[3] We made the same exercise for a data set without the brazilian crisis in it, from August 13th, 1998 through January 8,1999, obtaining very similar results in terms of impulse-response functions and variance decomposition.

FIGURE 7

VAR IMPULSE RESPONSE FUNCTIONS



Variance decomposition of the above VAR shows that during this period the variance to Mexican sovereign spreads is explained to a large extent by movements in Brazilian spreads, and that Russia does not contribute much to this variance. For the unhedged position and for the peso/dollar exchange rate, the amount of variance explained by Brazil is also sizable, around 30% and 50% respectively, after six weeks.

TABLE 9
VARIANCE DECOMPOSITION

Mexican sovereign spread

Days	S.E.	Russian sovereign spread	Brazilian sovereign spread	Mexican sovereign spread	Unhedged position in Mexican fixed rate securities	Peso/Dollar exchange rate
1	34.34	12.20	58.72	29.08	0.00	0.00
5	66.86	7.26	67.80	16.57	6.93	1.43
15	83.24	5.76	61.94	11.85	17.56	2.89
30	93.24	5.54	55.45	9.53	21.34	8.14

Unhedged position in Mexican fixed rate securities

Days	S.E.	Russian sovereign spread	Brazilian sovereign spread	Mexican sovereign spread	Unhedged position in Mexican fixed rate securities	Peso/Dollar exchange rate
1	170.44	0.90	1.58	2.67	94.85	0.00
5	327.72	2.62	17.10	4.73	75.45	0.10
15	517.91	2.08	32.85	5.37	57.43	2.27
30	621.93	1.85	33.76	4.33	52.28	7.78

Peso/Dollar exchange rate

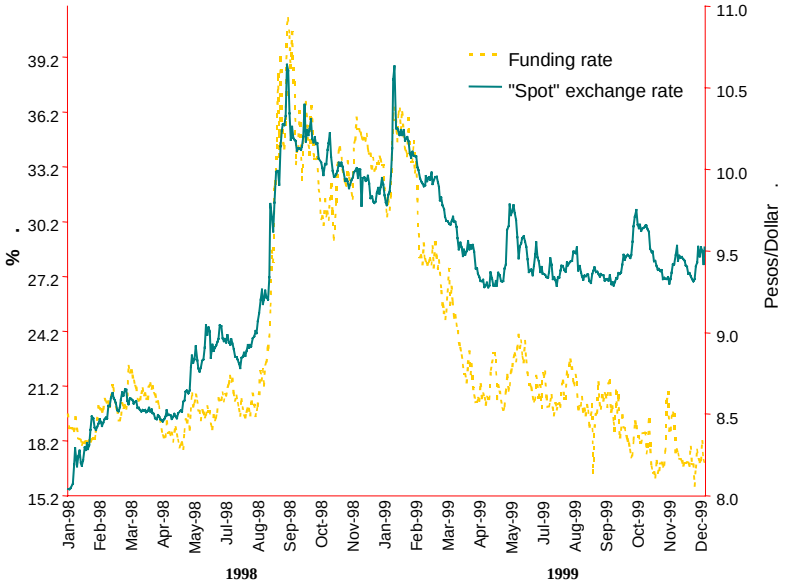
Days	S.E.	Russian sovereign spread	Brazilian sovereign spread	Mexican sovereign spread	Unhedged position in Mexican fixed rate securities	Peso/Dollar exchange rate
1	0.07	6.59	37.24	5.08	0.42	50.67
5	0.15	3.43	41.08	1.58	3.68	50.23
15	0.19	2.39	49.68	1.24	7.46	39.22
30	0.21	2.09	51.86	1.82	9.36	34.87

The Russian default and the intensification of speculative pressures in Brazil led to a severe contraction of capital flows towards emerging markets, that was reflected in a significant increase in emerging markets' sovereign debt spreads.

The drop in Mexico's terms of trade, and more importantly, the shutdown of international financial markets, resulted in an important depreciation of the exchange rate. Due to the openness of the Mexican economy and the high historical correlation between exchange rate depreciation and inflation, these currency movements had an important inflationary effect. Furthermore, an important proportion of the fiscal effort was derived from increases in the prices of goods and services provided by the public sector, complicating even more, the inflation outlook. The monetary authority reacted to these pressures by progressively tightening monetary policy, and short term interest rates went from a low of 17.75% in May, 1998 to 41.33% at the peak of the crisis.

FIGURE 9

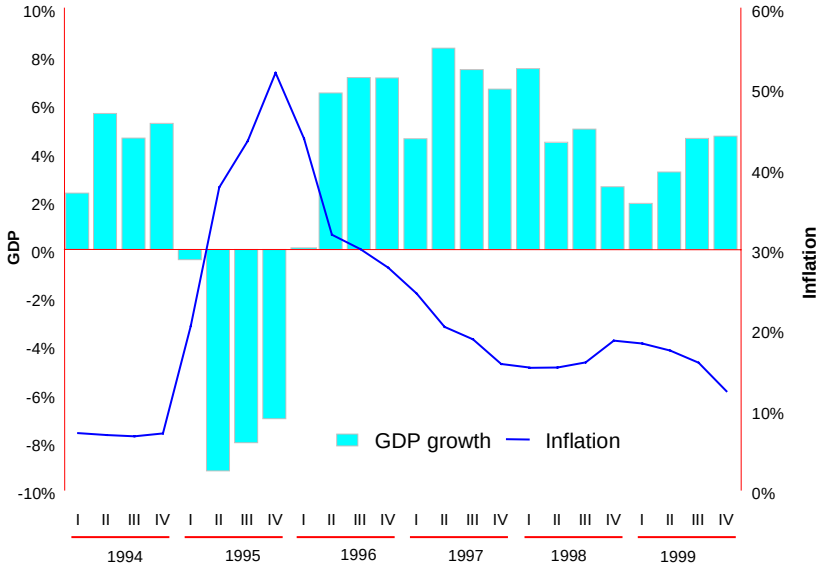
EXCHANGE RATE AND FUNDING RATE



Despite the crisis, the Mexican economy displayed a very favorable behavior during 1998-1999, even more so when we compare it to the behavior of other economies, both developed and emerging: GDP grew by 4.8 and 3.7%, employment by 7.8 and 6.1%[4], exports by 11.3 and 14.9% while international reserves increased. On the negative side, and because of the inflationary shocks described previously, the inflation rate deviated from its original 12% target by 6.6 percentage points and in 1999 the objective of an inflation below 13% was met.

[4] Percentage increase in number of workers affiliated to the Mexican Social Security Institute.

FIGURE 10
INFLATION AND GROWTH

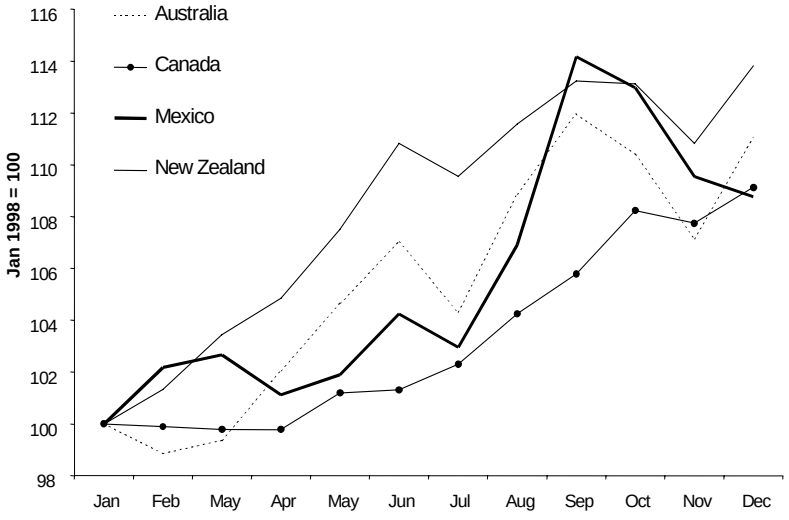


In addition to the quick policy reaction and the positive effects coming from a dynamic U.S. economy, the flexible exchange rate regime facilitated the adjustment of the real exchange rate towards the new equilibrium warranted by the external shock, without seriously affecting the credibility of the monetary authority. The best example of this role for the exchange rate is what we witnessed during 1998 with the currencies of Australia, Canada and New Zealand.

These small open economies were affected severely by the fall in the terms of trade of their economies and the fall in demand from the Asian crisis countries. As a reaction to these shocks, the currencies of these countries depreciated by large amounts. These currency movements were useful in diminishing the real effects of the aforementioned shocks. A similar phenomenon happened in Mexico, as our terms of trade fell by 5.5% and the international financial markets turned their backs on emerging markets. Both of these shocks should depreciate the equilibrium real exchange rate, justifying the observed depreciation of the currency.

FIGURE 11

REAL EXCHANGE RATE (1998)



*Real Exchange Rate against 55 countries (22 OECD countries and 23 Emerging Economies).
Calculated with WPI, PPI and CPI indexes.
Weighted with the trading patterns of manufactured goods of 1990. Source: J.P. Morgan

To evaluate the impact of these exchange rate depreciations on activity, it is useful to compare the behavior of these small open economies with floating exchange rates with that of countries with extremely rigid exchange rate arrangements such as Argentina and Hong Kong.

TABLE 11

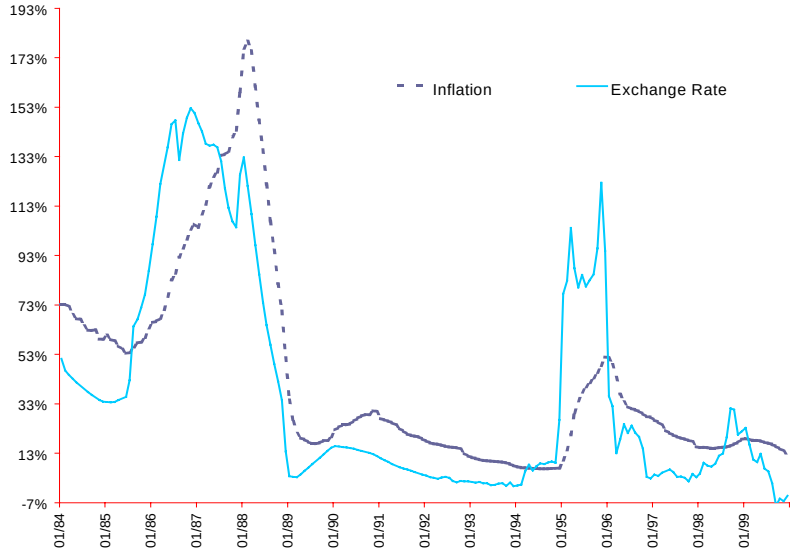
GDP GROWTH IN 1998 - 1999

	1998	1999
Argentina	3.9	-2.7
Hong Kong	-5.1	0.6
Mexico	4.8	3.7
Canada	3.1	3.7
Australia	4.8	4.8
New Zeland	0.3	3.0

Data: Goldman Sachs, JP Morgan, January 2000

However, given Mexico's history of high inflation and the high historical correlation exhibited between depreciation and inflation, as the exchange rate depreciated, inflation expectations immediately reacted. Therefore, the inflation cost of achieving the necessary correction in the real exchange rate was around 2.2 percentage points, and the nominal depreciation needed to achieve the same movement in the real exchange rate had to be significantly larger that the ones in the other countries considered.

FIGURE 12
INFLATION RATE AND PESO DEPRECIATION



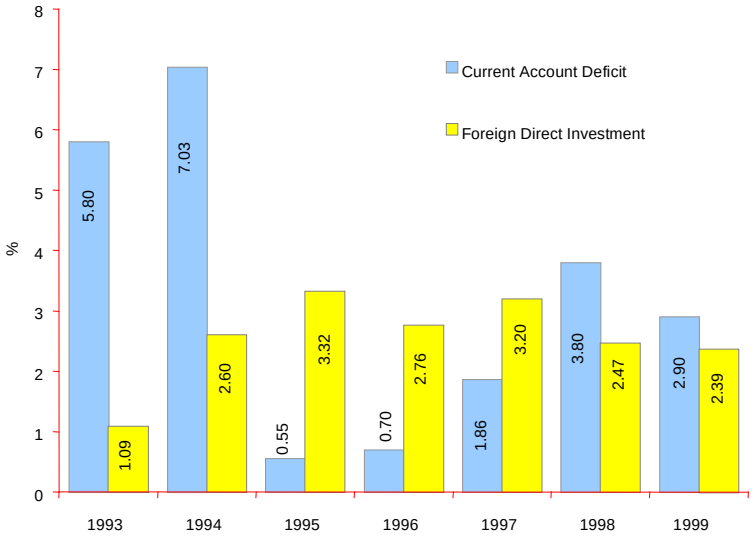
A brief comparison between the speed of the passthrough effects in Mexico and Australia highlights the problem the former faces due to its previous inflationary history. Although the long term impact of an exchange rate depreciation on non controlled prices is of the same order of magnitude in Mexico and Australia (a 1% depreciation translates into a 0.66% inflation in Mexico and 0.44% inflation in Australia), in Mexico half of this effect takes place after 2 quarters, while 82% takes place within the year. On the other hand, in Australia, only 7% takes place after 2 quarters and 14% after 4 quarters[5].

To reduce the high speed at which peso depreciations feed into inflation, is one of the key challenges that monetary policy faces in the future, so as for Mexico to be able to take advantage of the floating exchange rate regime and let the exchange rate play its "relative price" role instead of being a signal for future inflation.

Another important factor that contributed to reduce the impact of the international financial crisis on the Mexican economy is that the country has strengthened its non volatile sources of financing. Contrary to what happened in 1994, for the years 1997-1998, 65 % of current account financing came from long run capital inflows, FDI in particular. Additionally, the transfers made by Mexican residing in the U. S. reached

almost 6 billion dollars. In late 1997 the government negotiated with foreign banks a credit line for 1.69 billion dollars to be used in case of an adverse contingency. The government made use of this facility in September of 1998. Finally, certain private firms were able to obtain foreign financing from commercial bank credits, or from their own suppliers, or, in the case of foreign-owned companies, from their head offices overseas.

FIGURE 13
CURRENT ACCOUNT DEFICIT AND FOREIGN DIRECT INVESTMENT AS A PERCENTAGE OF GDP



[5] For details on these results see Garcés (1999).

IV. CONCLUSIONS:

In this paper we studied the contagion suffered by Mexico's financial markets from the most recent global financial crisis. Using several methodologies, we found that contagion was present in Mexico, particularly after the second wave of the Asian crisis, and was further intensified with the Russian default.

However, the Mexican economy suffered relatively mildly from the contagion of its financial markets because it was in a solid position to withstand these shocks. In this respect, it is important to highlight the positive effect that the dynamic U.S. economy has had on Mexico. In addition, the conservative fiscal and monetary policies followed, plus the strong liquidity position and low current account deficit, reduced the sources of vulnerability of the economy to these external shocks.

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