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EMERGING MARKET ECONOMIES: THE AFTERMATH OF VOLATILITY CONTAGION IN A SELECTION OF THREE FINANCIAL CRISES

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Resumen

Este artículo analiza el contagio en volatilidad producido por vínculos regionales e inter-regionales entre economías emergentes involucradas en tres episodios de crisis financieras. En particular, presenta una metodología que utiliza el premio soberano para determinar el rol ejercido por la volatilidad de la economía directamente afectada por una crisis, sobre el comportamiento de otras economías emergentes. Los principales resultados sugieren que sólo la crisis del Sudeste Asiático de 1997 tuvo efectos negativos tanto regionales como inter-regionales sobre otras economías emergentes, aumentando la volatilidad de sus premios soberanos. Por su parte, las crisis de México 1994 y Argentina 2002 habrían producido un impacto adicional menor sobre la estabilidad de los mercados internacionales de bonos emergentes.

Abstract

This paper examines the volatility contagion resulting from intra- and inter- regional links among emerging economies, on the basis of three major financial crises, namely Mexico 1994, East Asia 1997 and Argentina 2002. In particular, it presents a methodology that uses the sovereign bond spread as the financial time series to determine the impact of the volatility of the first-infected country on the behaviour of other emerging economies. Our main results reveal that only the Asia 1997 crisis had negative effects —both within and outside the region— on other emerging economies, in the form of increased sovereign spread volatility. On the other hand, the crises of Mexico 1994 and Argentina 2002 seem to have caused a minor additional effect on the stability of international markets for emerging bonds.

I would like to thank Giorgio Valente for his helpful comments and advice. All remaining errors are my responsibility.
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1 Introduction

After a sequence of emerging market crises during the 1990s, from Mexico 1994 to East Asia 1997 to Argentina 2002, there has been huge interest from both the academic field and market participants on, first, how to explain the dynamics of these crises and, to some extent, to anticipate this kind of events. Some of these studies have developed a number of useful indicators about how the market is assessing a specific region or country in terms of its latent risk.

Thus, a number of academics and practitioners have analysed the behaviour and interrelations between macroeconomic and financial time series, looking for explanations on a variety of questions, from predictability of external crises through intra- and inter-regional contagion episodes. Most of these studies are based upon a range of country-risk indicators derived from macroeconomic series, which are expected to capture the vulnerability of a particular economy over time. In addition, some works have empirically analysed contagion episodes by looking at financial time series such as exchange rates, interest rates and stock market returns, aiming at determining the relative importance of different channels through which contagion disseminates.

More recently, some studies have compared the economic behaviour of some of the most widely used measures of country risk, namely the excess return required on bonds issued by emerging economies in international markets, called the sovereign bond spread[1].

From the academic field, literature has presented a number of models that intend to replicate the framework within which currency crises occur. Thus, starting with a seminal paper by Krugman (1979), followed by Flood and Garber (1984), the so-called first-generation currency crisis models stress the role played by weak macroeconomic fundamentals together with misaligned policy stance, under a standard fixed exchange rate regime.

Later on, following the episode of the Mexican crisis in late 1994, a number of analytical papers dealt with the unsatisfactory approach derived from the main hypotheses behind first-generation models. These were unable to describe complete *stories* (see Sachs, Tornell and Velasco, 1996).

Thus, models based on self-fulfilling crisis episodes were derived by incorporating a loss function to their analysis, as in Barro-Gordon's model. In this sense, whenever an economy enters the multiple equilibria region, both 'good' and 'bad' equilibrium can be reached, depending on the economic policy stance and sudden changes in agents' expectations.

The latter is the cornerstone for the so-called third generation approach, which looks at modelling jumps in agents' expectations. Thus, the authorities are assumed to face a tradeoff between the costs of devaluing and keeping the exchange rate regime. Then, investors may select the optimal decision between rolling over debt or attacking the domestic currency —applying elements of moral hazard, based upon assumed government guarantees— depending on costs and benefits involved in each equilibrium, for instance, under atomised creditors.

More focused on contagion topics, a number of works have developed analytical models based upon particular channels of crisis contagion, being the most widely tested those related to trade linkages, financial links and competitive devaluation[2]. Thus, applying different approaches to determine the relative importance that each channel has shown in particular episodes of currency crises, studies have appeared successively. These have stressed first the role played by neighbourhood and, some subsequent extensions have explained the existence of inter-regional contagion in the most recent crises, such as the East Asian event and the Russian one.

Hence, the present analysis focuses on the relationship between a selected financial time series from a core set of countries specified for three currency crises, namely Mexico 1994, East Asia 1997 and Argentina 2002. A number of interesting issues arise from these events. First, neighbourhood effects in contagion dynamics may not be derived from the Mexican crisis. Second, most of the inter-regional features of contagion can be tested in the wake of the East Asian crisis, which affected not only countries in the region, but also other emerging economies with either fixed exchange rate or floating regimes. Finally, the most recent event of interest is the Argentinean currency crisis, given that it has originated an active debate in international markets involving both private institutions and official organisations.

In turn, the methodology to be applied is that presented in Edwards (1998) who conducts an analysis of volatility-style contagion using domestic interest rates for Argentina, Chile and Mexico during the Mexican crisis. At a first stage, the exercise considers the estimation of independent GARCH models for every country. At a second stage, an additional explanatory variable is included, namely the estimated conditional variance of the first attacked economy, i.e., Mexico, in the equation for the conditional variance for the rest of the countries in the sample.

Thus, the aim of this work is twofold. First, to review recent developments on financial crises and contagion literature. Second, to extend the empirical analysis presented in Edwards (1998) to the mentioned financial crises, using sovereign bond spread as dependent variable and including a longer list of economies from Latin America (Argentina, Brazil, Chile and Mexico) and East Asia (Korea, Malaysia, Philippines and Thailand). The periods under analysis are those

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[1] See, for example, Eichengreen and Mody (1998), Jaque and Rojas (2003) and Sy (2002).

surrounding the selected crises, using daily data available from May 1993 through July 2003. It is important to mention that this financial series allows for conducting this type of exercise since it involves high liquidity, which implies an appropriate reading of agents' performance, and free behaviour during the episodes.

The structure of this work is as follows: Section 2 reviews literature covering both theoretical developments on speculative attack models and contagion analytical and empirical studies. Section 3 presents the methodology to be applied and the analysis of the results. Section 4 concludes.

2 Literature Review

During the last decades the study of widely called financial crises has suffered some transformations, depending upon the main features that they have shown, in particular, regarding the effects both transient and 'quasi-permanent' they have implied for economies involved. In turn, most of these episodes have been labelled as Currency Crises, even though some authors have stressed differences between this kind of events and Banking Crises (Kaminsky and Reinhart, 1999). Thus, most of literature dealing with the latter type of crises has been developed under analytical models of bank runs, a microeconomic approach. Instead, since seminal paper by Krugman (1979), currency crises have faced new theoretical paradigms. Hence, recent academic literature focuses on so–called third-generation models that include game theory elements to model agents' behaviour when moral hazard considerations are involved.

2.1 On Currency Crisis Models: Focusing on Third Generation Approach

The need of endogenising agents' expectations change which causes the discrete jump from the prevailing equilibrium ex-ante a speculative attack, and the typically exhausted foreign reserves and floating exchange rate regime ex-post the attack is the base for developing the so-called third generation approach. These models involved moral hazard elements, which arises from assumed implicit guarantees by both external and internal agents, under a context of highly atomised creditors or bondholders, who either cannot or are not willing to support the prevailing equilibrium, for instance, rolling over the expiring debt. Hence, they do not realise that the country suffering from a financial crisis is only facing a transitory liquidity problem and it is not at an inter-temporal inconsistency of a sustainable policy.

[2] Dornbusch, Park and Claessens (2000) present a good review on contagion channels and the intuition behind them.

As argued in Sarno and Taylor (2002), most of the new approach has arisen after the East Asian crisis in 1997, which could not be satisfactorily explained by either first or second generation currency crisis models. Thus, new models have as main common factor the presence of moral hazard problem, given the implicit government guarantees taken into account in agents'investment decisions. Under this framework, asset prices bubbles can be generated, which finally could burst, prompting large capital outflows and the local currency collapse.

As a standard framework, it can be defined a system where three main groups of market participants interact. A first group involves external agents, as creditors and bondholders on domestic securities. The second group corresponds to the international financial community including the International Monetary Funds (IMF), regional development banks, among others. The third group consists of domestic agents, which includes the economic authorities, a financial sector (an intermediary sector) and domestic agents (corporations and individuals).

The interaction between these three groups has been the cornerstone for third-generation financial crisis models, which aim to endogenise the optimal decision made by each of these groups assuming the existence of both an implicit government guarantee and an international financial community one, creating a moral hazard problem. This factor is present in each link that can be thought between these groups. Thus, the first group, external creditors, will lend capital to a particular emerging economy assuming implicitly that the third group, the international financial community, is meant to be a so-called lender of last resort. Given this assumption, the risk taken by creditors would be greater than an optimal level considering no lender of last resort exists in international financial markets.

As presented in Miller and Zhang (1999), through moral hazard elements and game theory applications, the speculative attack timing occurred in the East Asian crisis can be explained under three views. First, the non-existence of creditor co-ordination could imply a stop in rolling over loans (Radelet and Sachs (1998)). Second, unsustainable indebtedness carried out by domestic agents, with assumed guarantees from government, together with highly reversible capital flows, could be halted (Dooley (1997) and Krugman (1998)). Third, a speculative attack could be led by large enough market agents given probable profits come from succeeding, even facing sounds macroeconomic fundamentals in the emerging economy.

Following this theoretical framework, the selected financial crisis episodes in this work, namely Mexico 1994, East Asia 1997 and Argentina 2002, use most of the elements behind the explanation for 'first speculative attack' movement that come from more recently developed analysis. Likewise, contagious effects over neighbour economies will have many elements described above, being the following section directly related to theory and empirical findings on contagion issues.

2.2 On Contagion: Recent Theoretical Developments and Empirical Evidence

Both, analytical and empirical works, have focused on the alternative channels through which a financial crisis in a particular economy, 'first attacked', can be propagated to other economies. Then, as a starting point it is necessary to recall an accurate definition for contagion. Throughout this work, contagion is expected to imply a negative behaviour of an economy after having observed a successful speculative attack to another country. The main feature to define contagion is that the 'first attacked' economy shows certain weakness before being attacked, whereas the 'infected' country shows sounds macroeconomic fundamentals and no troubles related to those, for instance, considered in third-generation currency crisis models[3].

The channels through which contagion occurs will depend on the group of countries and the particular crisis episode under study. Hence, as presented in Dornbusch, Park and Claessens (2000), the main three channels for financial contagion are trade links, financial links and competitive devaluation. To some extent, these propagating factors can be viewed as fundamental ones, i.e., the existence of trade links between any pair of economies will spread the shock from the first attacked economy to the second one. Indeed, given the negative effects and consequences that a speculative attack can encompass for the macroeconomic performance of the attacked economy, it is highly probable that these effects mean a negative shock to the second economy.

In particular, financial links are related to some of the elements involved in third-generation models, namely no co-ordinated actions from creditors and the presence of a high concentration of creditors supporting liquidity requirements from a particular set of countries. Thus, portfolio management strategies, liquidity shortfalls, fund runs, among others may well explain the decision of calling earlier most of the instruments held by international investors from an entire region, thus propagating the financial crisis from the initially attacked economy to its neighbours.

From the viewpoint of the empirical evidence, Hernandez and Valdés (2001) use both stock indexes and sovereign spreads to determine the relative importance of alternative contagion channels, namely trade links, financial competition and regional links (neighbourhood)[4]. They

[3] Nonetheless, this definition of contagion is biased under the World Bank extended definition. The latter considers both positive and negative propagation as contagion. Hence, when analysing just one side of the phenomena, in this case the negative one, response measurement could be biased. However, this paper considers 'negative' contagion, allowing for positive one through an asymmetric specification applicable for 'good' and 'bad' news context.

[4] Sovereign bond spreads are used given their statistical advantages as high frequency data and large set of countries available.

find, after analysing Thai 1997, Russian 1998 and Brazilian 1999 crisis episodes that the financial competition turns out to be the most important channel behind contagion, when using sovereign bond spreads as dependent variable. This is particularly relevant when testing for inter-regional contagion, as in the present work.

In turn, Edwards (1998) deals with volatility contagion between a trio of Latin American economies, namely Argentina, Mexico and Chile, through analysing the performance of interest rates during the Mexican crisis episode in late 1994. The essence of this type of contagion measurement is to conduct tests on the significance that the first attacked country volatility has in the infected economies interest rate ones. His findings provide a number of interesting issues. First, Mexican crisis did not infect the Chilean economy, whereas Argentinean economy showed a clear negative effect caused by the Mexican variable dynamics. Second, through applying volatility co-movement as a contagion indicator, it is not necessary that the infected economy ends up floating its exchange rate, i.e., abandoning the prevailing pegged regime, which applies for the Argentinean case.

Nonetheless, when using an alternative dependent variable, for instance, sovereign bond spread, it may be possible to measure contagion through volatility co-movement in either the case when a particular economy had not abandoned its prevailing exchange rate regime or, alternatively, local markets had not shown an increase in their volatility. In addition, using sovereign bond spread presents advantages for the extension proposed in the present paper, i.e., to cover more countries under the selected crisis episodes, considering a dependent variable that presents high frequency data.

The next section shows a detailed description of the methodology applied in this work, following the standard econometric tests for volatility analysis used in the literature and the framework presented in Edwards (1998) for volatility contagion.

3 Volatility Contagion Methodology

The methodology to be applied to determine the existence of volatility-style contagion among the core set of countries selected for each of the crisis episodes under study follows the analysis developed in Edwards (1998). As mentioned, the paper presents an empirical work on domestic interest rates for three Latin American countries (Argentina, Chile and Mexico), in the wake of the Mexican crisis in 1994. Given that the present work looks for expanding this analysis, it includes the East Asian and Argentinean crises, incorporates additional countries, and considers sovereign bond spread as dependent variable.

Thus, countries included are Argentina, Brazil, Chile and Mexico for Latin America, and Korea, Malaysia, Philippines and Thailand for East Asia.

In turn, the main reason to consider the sovereign bond spread as dependent variable is it allows for co-movement analysis under fairly high liquidity conditions. However, alternative financial series, for instance exchange rate forwards, have been introduced in emerging economies in the last years. Thus, a natural extension of this work would be trying to conduct this kind of methodology over these derivative contracts. Theses allow for high enough liquidity and co-movement during the pre and post-crisis window, across a particular region, even though an infected country may decide not to devalue in the end[5].

In addition, this section aims to provide an analysis in terms of the response shown by sovereign bond spreads before shocks. It is well known that the standard financial time series performance have inspired a number of studies in terms of the behaviour of their volatility, measured through the variance of their return, looking for asymmetries arriving from positive and negative shocks as well.

Thus, a standard procedure involves, first, to determine the presence of an autoregressive process in the variance, known as ARCH (Autoregressive Conditional Heteroskedasticity) modelling, first introduced by Engle (1982). The explanatory power of lags of squared residuals on the current realisation of themselves is tested under this specification. Generalisations of this methodology, allowing for autoregressive specification on the conditional variance came later on, finally deriving in the most currently used methodologies, namely asymmetric modelling on generalised autoregressive conditional heteroskedasticity, AGARCH models.

Hence, this work applies the latter approach to sovereign bond spreads of the countries considered in the sample.

The exercise is structured as follows: In Section 3.1, ARCH presence is tested on the level of sovereign bond spreads[6]. After detecting ARCH processes in these series, common asymmetric specification is presented for each variable, particularly, a pure Threshold GARCH specification following Glosten, Jaganathan and Runkle (1993). Then, through estimating the model proposed, asymmetric responses to 'good' and 'bad' news are evaluated looking at the sign taken by the disturbance term, as well as the significance of the parameter associated to the

[5] In the case of Argentine Peso, forward contracts internalised the pegged regime abandonment months before it occurred, thus allowing for volatility estimations.

[6] Although unit root tests provide evidence of I(1) variables in this case, these tests have low power in the presence of structural breaks in the time series.

asymmetry included in the specification[7].

In Section 3.2, volatility contagion exercises are run under the following structure: first, three one-year periods are taking into account: December 1994-November 1995, January-December 1998[8], and July 2001-June 2002. Second, TGARCH-X models are run over these periods for Latin American and East Asian countries, including the conditional variance already estimated for Mexico, Thailand and Argentina as an explanatory variable (X term), in order to test for volatility contagion over the rest of the countries in the sample. Conditional variances included are non-negative given restrictions imposed over the parameters when original regressions are run.

3.1 Independent Model Estimations

As mentioned, a first step is to test for ARCH process presence. Thus, Table 1 presents results of these tests, which report evidence for this phenomenon in the variance of the residuals in each spread series. In the case of Thailand and Malaysia, the null hypothesis of non-ARCH process cannot be rejected at 1% significance level, but only at 10% significance level. However, exercises on GARCH modelling presented later on provide evidence of meaningful parameters in this type of specification in both cases.

The generic mean equation for country *i*, considered to conduct this test, is as follows:

$$Spread_{i,t} = \phi + \sum_{j} \lambda \cdot Spread_{i,t-j} + \varepsilon_t \qquad (1)$$

where, the second term in the right-hand side accounts for lags included in this simple specification for the level of sovereign bond spreads.

Hence, the following step involves the estimation of the asymmetric GARCH model, which is modelled to take into account the autoregressive process of the volatility. The regressions follow the specification:

$$h_t^2 = \varpi + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 D_{t-1} + \beta h_{t-1}^2 + \mu_t \qquad (2)$$

where, D_{t-1} equals one if $\varepsilon_{t-1}<0$, considering the threshold model selected in this work.

[7] Procedure presented by Engle and Ng (1993), in order to evaluate the asymmetric impact of good news ($\varepsilon_{t-1}<0$) and bad news ($\varepsilon_{t-1}>0$) over the conditional variances.

Estimation procedure is specified in order to ensure covariance-stationary, i.e., imposing restrictions over estimated parameters to prevent conditional variance from exploding. Thus, the inequality $[(\alpha+\gamma)/2 + \beta] < 1$ must hold in the estimation output. In addition, conditions for nonnegativeness of the conditional variance are stated, i.e., $\omega>0$, $(\alpha+\gamma)/2\geq0$, and $\beta>0$, which ensure positive values for conditional variance[9].

Results are summarised in Table 2 and 3 for Latin American and Asian countries, respectively, where estimated parameter for each TGARCH are presented. They are conducted under a simple modelling for mean equation; thus, each exercise considers an AR(1) process for the mean of the level of sovereign bond spreads.

In Table 2, TGARCH regressions for Latin American countries provide mixed results. In the case of Argentina, the parameter accounting for the asymmetric response to shocks is non-significant, while α and β are meaningful, thus implying that the conditional variance of the Argentinean spread presents a symmetric behaviour. In the case of Brazil, parameters included in this specification are meaningful, though the parameter that captures the asymmetric response presents a positive sign. This means that whenever a negative shock occurs, good news in this case given the decrease in the country-risk measure, the impact on the conditional variance increases in $[0.08*\varepsilon^2_{t-1}*1>0]$, component that does not enter the equation under positive shocks. Thus, the conditional variance increases faster whenever the Brazilian sovereign spread decreases[10].

In the cases of Chile and Mexico, all the parameters are significant and support the presence of an asymmetric response to shocks. In particular, the parameter associated to this element presents a negative sign in these estimations, which is consistent to the expected result. Thus, the conditional variance of sovereign spread increases faster whenever a positive shock arrives, i.e., given an unexpected increase in the spread in the previous period. Conversely, under negative shocks, i.e., good news for the country risk measured by the sovereign spread ($\varepsilon_{t-1}<0$), the impact on the conditional variance at time t is reduced by $[\gamma*\varepsilon^2_{t-1}*1<0]$, given $\gamma<0$ in these cases. Thus, when sovereign spreads decrease unexpectedly (good news), the impact on the conditional volatility is lower than the impact due to a positive shock (bad news).

In Table 3, TGARCH regressions on East Asian countries deliver results supporting the

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8 East Asian exercise is restricted, since data are available only from January 1998 for EMBI Global spreads.

9 This is relevant when including the estimated conditional variance of the first attacked economies as an explanatory variable in the equation of the conditional variance of the rest of the countries.

10 This result would be considered counter-intuitive, since it would have been expected a faster response of sovereign spreads to positive shocks, i.e., bad news for this country risk indicator.

existence of asymmetric responses to positive and negative shocks, with the exception of Thailand, which presents a non-significant parameter associated to the asymmetric component. Thus, in the case of Malaysia, provided quite similar magnitudes for parameters α and γ, this asymmetry is relevant, and its magnitude can be calculated as $[-0.04*\varepsilon^2_{t-1}*1<0]$, which is the reduction in the conditional variance given a negative shock.

In the case of Korea and Philippines, both countries show significant parameters for the asymmetric term in the variance equation, being relatively smaller than α, the parameter associated directly to the square residuals in equation (2).

Therefore, considering the results obtained for Latin America and East Asia, there is evidence of asymmetry from TGARCH methodology applied to sovereign bond spreads. This supports the argument that the impact from negative shocks, in this context meaning good news, are lower than the impact derived from positive shocks of the same magnitude, bad news, over the conditional variance in this modelling.

The economic interpretation may be that positive shocks, an unexpected increase in sovereign bond spreads over time associated to higher country risk assigned by investors, impacts more significantly the perception of international financial markets. An unexpected decrease in sovereign spreads provides a lower impact. Thus, in addition to the objective of this kind of volatility modelling, which allows for conditional variance clustering[11], bad news arriving to markets of a particular economy tends to induce higher volatility than those generated by good news arrivals. As mentioned, this does not hold in the case of Brazil that shows an inverse result, given the positive sign of the estimated parameter associated to the asymmetric component.

3.2 Testing for Volatility Contagion

After having estimated TGARCH regressions using the full sample available in each case, the next step is to estimate the significance of each conditional variance series estimated in the previous section for the first attacked economies over the rest of the countries. Thus, the exercise, as mentioned, involves the estimation of TGARCH models in the three one-year periods selected, all of them starting at the moment that agents begin to internalise a higher risk measured by the sovereign bond spread. These regressions include the estimated conditional variance for Mexico, Thailand and Argentina, series included as explanatory variables in the TGARCH models for the rest of the economies in the sample, as follows:

[11] Volatility clustering is a well-known phenomenon in financial time series, which implies that high volatility tends to persist over a time window, and the same can be observed for low volatility realisations. Hence, GARCH models incorporate lags of conditional variance as explanatory variable.

$$h_t^2 = \varpi + \alpha\varepsilon_{t-1}^2 + \gamma\varepsilon_{t-1}^2 D_{t-1} + \beta h_{t-1}^2 + CVX_t + \mu_t \qquad (3)$$

where, CVX term corresponds to the estimated conditional variance for the first attacked country.

Results are presented for every financial crisis episode, reporting estimated equations for each region. Thus, Table 4 shows estimations for Latin American economies, which have available data in the period December '94 to November '95. In particular, there is no available data for East Asian and Chilean economies to conduct this test in this episode, thus only Argentina and Brazil models are re-estimated in order to detect the presence of volatility contagion. As can be seen, both estimations provide no evidence of spillover from the Mexican conditional variance (CVMex) on the estimated conditional variance for Argentina and Brazil, at standard levels of significance.

Thus, when using sovereign bond spreads in order to conduct volatility contagion exercises, no additional explanatory power is derived from including the conditional volatility of the first attacked economy, Mexico, in this crisis episode. This result differs from that reported by Edwards (1998), who applies this methodology to short term interest rates and finds evidence of contagion from Mexico over Argentina.

Despite the fact that Latin American sovereign bond spreads increased during that period, all the behaviour of the conditional volatility of Argentina and Brazil is captured by the independent TGARCH models run over this particular period.

With regard to the East Asian crisis, as mentioned, available data allow for conducting this test in the period January-December 1998, including the pool of countries both Latin American and East Asian economies. Thus, results are reported in Table 5 and 6, respectively.

For Latin American economies, the exercise provides significant evidence of volatility contagion. Thus, considering models run for Argentina, Brazil and Mexico, the parameters associated to the estimated conditional variance of Thailand (CVThai) are statistically significant. Hence, the increase observed in the volatility measure for Thailand, the first attacked country in mid-1997, impacted upwards the volatility measure in the case of Latin American economies in 1998. This supports the hypothesis of volatility contagion in the wake of the East Asian financial crisis and gives support to those theories that state inter-regional contagion in the most recent episodes, through financial contagion channels.

It must be recalled that this type of contagion involves channels such as that related to portfolio investment management. This implies that managers, who have invested in a wide range of emerging market economies, once facing liquidity requirements or margin calls, attempt to sell fairly valued assets, thus affecting the rest of the economies that may be showing sound and stable economic stances.

With respect to the effect of the Thailand crisis over the rest of East Asian economies, Table 6 reports results obtained. As can be seen, the parameter associated to CVThai is significant at any standard level and positive in regional regressions. As could be expected a priori, a clear effect can be found when considering neighbours of the country that suffers the speculative attack. In particular, in the case of the East Asian crisis, most of the elements mentioned in the recent literature review the weakness of the domestic financial sector in the region, which played an important role in propagating the attacks to domestic currencies throughout East Asia.

Finally, the analysis run over the Argentinean crisis provides new evidence for volatility contagion and how the international agents react after having faced a number of crises during the last decade.

Thus, results are reported for Latin American and Asian economies in Table 7 and 8, respectively. As can be observed in Table 7, the parameter associated to the estimated conditional variance of the Argentinean spread (CVArg) is statistically significant only in the case of Chile, though it is virtually zero. Thus, results give a null economic weight to this variable in the performance shown by Latin American economies in the sample.

One of the most plausible explanations for this behaviour can be derived from the quite different economic environment faced for the three economies involved in the analysis. Thus, Mexico, which floated its currency in early 1995, Brazil, which did the same in early 1999 and Chile, which had abolished its exchange rate band in September 1998, had fairly free exchange rate markets at that moment. In addition, all these economies had carried out sound financial liberalisation process, though it must be considered the crisis episodes suffered by Mexico (1994) and Brazil (1999). Moreover, it is probable that international agents had managed in a better way the individual information from each country. Regarding this argument on a well-ordered neighbourhood, it can be raised the point that a focalised crisis does not increase the conditional probability of contagion episodes, as derived from Kaminsky and Reinhart (2000). Moreover, this statement is supported by the inter-regional results obtained in the case of the East Asian crisis, episode that finally involved a number of countries, propagating effects to other regions.

From Table 8, similar results are obtained for East Asian countries. Although all the estimated parameters are statistically significant, they are negligible. Therefore, it can be inferred that there exists no evidence of volatility contagion from Argentina over this group of economies. Among factors behind these results, it must be considered that, first, most of the creditors supplying loans to East Asia are Japanese, even though it must be regarded that capital flows to that region show a sharp decrease after the East Asian crisis. In turn, the most important creditors of Latin America, in particular of Argentina, come from the US.

In addition, same argument as before can be raised, given that this episode presents an isolated event, after all the countries in that region had already suffered post-crisis adjustments during the 1990s.

4 Conclusions

The aim of this work is twofold. First, to review recent developments on financial crises and contagion literature. Second, to extend the empirical analysis presented in Edwards (1998) to a selection of three financial crises, namely Mexico 1994, East Asia 1997 and Argentina 2002. The present paper considers a longer list of emerging countries from Latin America (Argentina, Brazil, Chile and Mexico) and East Asia (Korea, Malaysia, Philippines and Thailand) and uses sovereign bond spread as dependent variable.

The empirical purpose deals with applying an appropriate technique to test volatility contagion over financial crises. In particular, the well-known approach of generalised autoregressive conditional heteroskedasticity, GARCH modelling, is conducted following an asymmetric specification.

In the first step, the asymmetric modelling is presented following a pure Threshold GARCH, over sovereign bond spreads, the excess return required by international investors on bonds issued by emerging market economies, denominated in foreign currency. These bonds, traded in international markets, present high enough liquidity and frequency, which allow for conducting this type of exercise.

Thus, after determining the existence of asymmetric responses to good and bad news entering the markets, a second step deals with determining whether there is a volatility-style contagion among countries involved in an episode of financial crisis. Through including the estimated conditional variance of those countries first attacked in each episode into the conditional variance equation of the rest of the economies in the sample, the test looks for the presence of contagion by determining the statistical significance of this new term.

Results from this exercise are mixed and depend on the features of the different economies involved in each crisis, at the moment they were triggered. Thus, in the wake of the Mexican crisis, Argentina and Brazil present no evidence of volatility contagion. With these results, the behaviour shown by the conditional volatility of these countries is well captured by the independent TGARCH model estimated.

With regard to the East Asian crisis, all the Latin American countries considered reveal a significant impact of the financial crisis initiated in Thailand. As expected, East Asian economies suffer an important impact in their measure of conditional variance as well, being Korea and Philippines the most affected, followed by Malaysia, which registers a significant but relatively small parameter for the estimated conditional variance of Thailand.

In turn, when reviewing the Argentinean crisis occurred in 2002, different results appear. Although estimated parameters are statistically significant for the entire sample of economies considered in this paper, all of them are virtually zero. These results provide a negligible economic weight to Argentina's estimated conditional variance in explaining the dynamics of the financial volatility of the rest of the economies in Latin America and East Asia.

Finally, regarding the empirical results obtained for conditional variance behaviour of the sovereign bond spreads under the three selected crisis episodes, a number of issues developed in the literature on financial crises are appropriate to explain the dynamics of these events. In particular, the empirical analysis helps understand the dynamics behind each episode, giving a relevant role to financial contagion channels in the wake of the most recent financial crises in the world.

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Appendix A: Data Description

The financial time series used in the analysis of volatility contagion are sovereign bond spreads, considering windows that include pre and post-crisis periods. In addition, the empirical exercises involve GARH modelling for both individuals and extended models. The latter consider the estimated conditional variance for the first attacked country as an explanatory variable for each pre-post crisis period. First attacked economies are Mexico in 1994, Thailand in 1997 and Argentina in 2002.

The time series used to carry on this work are sovereign bond spreads quoted in daily frequency by JP Morgan Chase & Co., considered in its widely used Emerging Markets Bond Index (EMBI), from May 1993 through December 1997, and EMBI Global from January 1998 through July 2003[12].

In the case of Latin America, data availability allows for conducting the exercises for Argentina, Brazil and Mexico over the three selected crises, whereas Chilean spread is available only since late April 1999[13], being considered only in the Argentinean episode.

In the case of Asian countries, the sample is more restricted. Philippines is available for the entire period –though missing data are present during 1997. In turn Korea, Malaysia and Thailand present data from January 1998 through July 2003 (from EMBI Global). All of them allow for conducting the exercises in the East Asian and Argentinean crisis periods.

In addition, the sovereign bond spread is measured by the excess return over a US Treasury note (considering an appropriate on-the-run bond according to duration features) and is denominated in basis points (1% equals 100 basis points). Thus, for Latin American sample, Argentinean, Brazilian and Mexican series account for a weighted average of bonds issued on international markets, presenting a high liquidity and presence in emerging economy debt markets (EMBI standards).

On the other hand, yet Chilean series is based on quotations from the same source, it only considers the first issuance in the international capital markets made by Chile, i.e., the ten-year maturity bond issued in April, 1999, denominated in US dollars, until 2002. From that year on, new issues have been included in the weighted average, namely 2002 both ten and five-year bond issues, and 2003 ten-year bond issue. Likewise, Asian sovereign bond spreads are constructed following the same standards.

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[12] EMBI indicator considers issuance denominated in foreign currency that fulfil conditions on liquidity, outstanding amount issued, among other market factors. EMBI Global measure includes a wider variety of debt instruments, following similar standards, but incorporating a longer list of issuer countries.

[13] Date of the first sovereign bond issuance.

Appendix B: Tables

Table 1: Sovereign Bond Spreads, ARCH Test

Latin America (1)				
Argentina	F(1,2559)	21.294	0.000	**
Brazil	F(1,2892)	195.01	0.000	**
Chile	F(1,1065)	132.82	0.000	**
Mexico	F(1,2892)	316.53	0.000	**
East Asia (1)				
Korea	F(1,1389)	8.4019	0.004	**
Malaysia (2)	F(1,1379)	3.6226	0.057	
Philippines	F(1,1384)	12.642	0.000	**
Thailand	F(1,1379)	2.9493	0.086	

(1) All the tests consider five lags to determine the existence of ARCH effects.
(2) Test considers 10 lags. Under 5 lag specification p-value of 0.12 is reported.
(**) Denotes rejection of null hypothesis of no ARCH process at 1% of significance level.

Table 2: Latin America, TGARCH (1,1) on Sovereign Bond Spreads

Dependent Variable Arg Spread
Observations: 2571

Variance Equation	Coefficient	t-Statistic	Prob.
ω	16.91	2.44	0.015
α	0.21		
γ	-0.07	-1.64	0.100
β	0.79	16.9	0.000

Dependent Variable Br Spread
Observations: 2904

Variance Equation	Coefficient	t-Statistic	Prob.
ω	0.00		
α	0.14		
γ	0.08	2.05	0.041
β	0.86	28.7	0.000

Dependent Variable Cl Spread
Observations: 1077

Variance Equation	Coefficient	t-Statistic	Prob.
ω	14.27	2.42	0.016
α	0.42	2.66	0.008
γ	-0.25	-2.22	0.027
β	0.40	2.29	0.022

Dependent Variable Mex Spread
Observations: 2904

Variance Equation	Coefficient	t-Statistic	Prob.
ω	7.64	3.18	0.002
α	0.21		
γ	-0.09	-3.72	0.000
β	0.79	21.30	0.000

Table 3: East Asia, TGARCH (1,1) on Sovereign Bond Spreads

Dependent Variable Kor Spread
Observations: 1401

	Coefficient	t-Statistic	Prob.
ω	1.71	2.31	0.021
α	0.13	4.53	0.000
γ	-0.09	-3.67	0.000
β	0.87	30.10	0.000

Dependent Variable Mal Spread
Observations: 1401

	Coefficient	t-Statistic	Prob.
ω	0.61	1.74	0.082
α	0.06		
γ	-0.04	-2.81	0.005
β	0.94	37.50	0.000

Dependent Variable PHP Spread
Observations: 1401

	Coefficient	t-Statistic	Prob.
ω	5.46	3.01	0.003
α	0.18		
γ	-0.09	-2.77	0.006
β	0.82	20.90	0.000

Dependent Variable Thai Spread
Observations: 1401

	Coefficient	t-Statistic	Prob.
ω	1.60	1.17	0.243
α	0.11		
γ	-0.002	-0.06	0.949
β	0.89	17.30	0.000

Table 4: Mexico 1994, Latin American TGARCH-X (1,1)

Dependent Variable Arg Spread
Observations: 251

Variance Equation	Coefficient	z-Statistic	Prob.
ω	275.62	2.80	0.005
α	0.55	3.24	0.001
γ	-0.56	-3.37	0.001
β	0.61	5.00	0.000
CVMEX	0.05	1.10	0.272

Dependent Variable Br Spread
Observations: 251

Variance Equation	Coefficient	z-Statistic	Prob.
ω	80.69	2.63	0.008
α	0.54	2.82	0.005
γ	-0.55	-2.91	0.004
β	0.56	3.42	0.001
CVMEX	0.03	1.35	0.176

Table 5: East Asia 1997, Latin American TGARCH-X (1,1)

Dependent Variable Arg Spread
Observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	1376.07	4.96	0.000
α	0.49	4.99	0.000
γ	-0.33	-1.63	0.102
β	-0.09	-2.45	0.014
CVTHAI	0.63	6.46	0.000

Dependent Variable Br Spread
Observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	1516.98	4.03	0.000
α	0.18	3.37	0.001
γ	-0.005	-0.03	0.975
β	-0.45	-2.81	0.005
CVTHAI	1.29	3.84	0.000

Dependent Variable Mex Spread
Observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	557.24	4.62	0.000
α	0.10	6.80	0.000
γ	0.10	2.08	0.038
β	-0.87	-26.02	0.000
CVTHAI	1.20	6.96	0.000

Table 6: East Asia 1997, East Asian TGARCH-X (1,1)

Dependent Variable Kor Spread
Observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	117.20	4.01	0.000
α	0.04	1.16	0.248
γ	-0.08	-2.17	0.030
β	-0.82	-12.99	0.000
CVTHAI	0.72	9.68	0.000

Dependent Variable Mal Spread
Observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	18.23	1.71	0.086
α	1.61	4.72	0.000
γ	-1.57	-4.56	0.000
β	-0.02	-0.32	0.752
CVTHAI	0.32	6.08	0.000

Dependent Variable PHP Spread
Observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	-6.28	-0.26	0.795
α	-0.03	-1.18	0.239
γ	0.01	0.65	0.518
β	-0.72	-6.82	0.000
CVTHAI	1.05	10.71	0.000

Table 7: Argentina 2002, Latin American TGARCH-X (1,1)

Dependent Variable Br Spread
Included observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	133.67	4.56	0.000
α	0.58	3.54	0.000
γ	-0.67	-4.12	0.000
β	0.50	6.07	0.000
CVARG	-0.00017	-0.51	0.607

Dependent Variable CL Spread
Included observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	28.55	6.45	0.000
α	0.28	2.04	0.042
γ	-0.04	-0.23	0.820
β	0.05	0.35	0.729
CVARG	-0.00017	-10.62	0.000

Dependent Variable Mex Spread
Included observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	7.17	1.64	0.101
α	0.20	3.32	0.001
γ	-0.19	-2.78	0.005
β	0.79	7.96	0.000
CVARG	-0.00001	-0.32	0.748

Table 8: Argentina 2002, East Asian TGARCH-X (1,1)

Dependent Variable Kor Spread
Included observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	24.29	4.67	0.000
α	0.23	2.41	0.016
γ	-0.26	-2.54	0.011
β	-0.11	-0.68	0.496
CVARG	0.00058	4.46	0.000

Dependent Variable Mal Spread
Included observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	0.34	3.17	0.002
α	0.03	1.50	0.134
γ	-0.05	-2.42	0.016
β	0.98	63.98	0.000
CVARG	-0.00001	-4.75	0.000

Dependent Variable PHP Spread
Included observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	70.05	5.43	0.000
α	0.38	2.01	0.044
γ	-0.17	-0.90	0.366
β	0.17	1.15	0.250
CVARG	-0.00048	-5.18	0.000

Dependent Variable Thai Spread
Included observations: 248

Variance Equation	Coefficient	z-Statistic	Prob.
ω	52.00	10.55	0.000
α	2.81	4.95	0.000
γ	-1.82	-3.05	0.002
β	0.01	0.31	0.756
CVARG	-0.00029	-1.82	0.069

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