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Volatility spillovers and contagion: an empirical analysis of structural changes in emerging market volatility

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Abstract

This paper aims to test the international transmission of stock market volatility and the risk of contagion among a sample of emerging and developed markets through a methodology rarely used in this context. This methodology, developed by Bai and Perron (1998, 2003), is based on the determination of structural breakpoints. Our empirical strategy consists in identifying similarities in the dates of structural breaks and in comparing them with the occurrence dates of financial crises in order to test respectively the international transmission of volatility and the risk of contagion. Empirical results lead to very interesting conclusions. First, we find that the transmission of volatility is effective between the emerging markets and between them and the developed ones. Second, we show that the geographical proximity has a crucial effect in the transmission of volatility. Finally, a comparison between the occurrence dates of financial crises and the different structural breakpoint dates allows us to notice that there is an important analogy between them. This proves that the financial shocks are transmitted from one market to another during the periods of crises.

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1. Introduction

An important degree of financial integration, close to unity in emerging markets[1], is synonym of financial and economic interdependencies either among emerging economies or between them and the developed ones (Nguyen, 2005; Phylaktis and Ravazzolo, 2002; Masih and Masih 1999; Longin and Solnik, 1995). These authors define economic interdependence as an economic event located in a country and affecting other economies mainly through commercial and/or financial flows. Besides, it has been argued that interdependencies are more important within the stock markets because financial markets have always quick and instantaneous reactions to the information (Nguyen, 2008). These financial interdependencies constitute a support of rapid transmission of shocks as financial markets react immediately to news.

The financial literature has recently focused on the study of the volatility transmission, i.e. the spillover effects. Indeed, many studies tried to treat the spillover phenomenon in emerging markets. In their empirical research, they proved the existence of unidirectional and bidirectional spillover among the different international stock markets. This fact became more amplified after a strong integration (Li, 2007; Choudhry, 2004; Darrat and Benkato, 2003; Xu and Fung, 2002; Caporale et al., 2002; Kasch-Haroutounian and Price, 2001). More recently, and with the multiplicity of financial crises in the emerging economies, the financial literature has focused on studying the transmission of volatility in periods of crises in the emerging markets and especially on the identification of the transmission mechanisms (Bekaert et al., 2005; Forbes and Rigobon, 2001, 2002; Pritsker, 2001; Masson, 1999).

Many studies, such as those of Forbes and Rigobon (2002), Bailey et al. (2003) and more recently Nguyen (2008), have shown that the transmission of volatility is based on several channels. We mention particularly the introduction of new financial instruments, which facilitates the international integration such as the ADR (American depositary receipt) and the country funds, the coordination arrangements in terms of monetary or economic policies and economic partnerships, and finally the geographical proximity that can be considered as the last channel of the transfer of volatility among markets because the movement of capital flows are easier and faster.

This paper contributes to the literature in that it aims to study the interdependencies of volatility between financial markets. Indeed, it is based on the analysis of volatility spillover in normal periods (transmission) and in times of financial crises (contagion). Nevertheless, and unlike previous works, we adopt a more appropriate methodology in the context of stock markets that are generally characterized by the presence of multiple regimes in the variance (Nguyen, 2008; Bensafta and Semedo, 2011), and which is rarely used in this context. This technique is based on the determination of structural breaks developed by Bai and Perron (1998, 2003). The empirical strategy is based on identifying similarities in structural break dates between different markets to test the international transmission of volatility and on comparing the occurrence dates of financial crises with the structural break dates in order to verify the risk of contagion. By using this strategy, we take into account an important feature characterizing the international financial markets and especially those of emerging economies, namely the proliferation of financial crises over the past three decades and consequently the contagion that occurred.

The remainder of this paper is organized as follows: In the second section, we define the two concepts of transmission and contagion. In the third section, we present the literature review related to these concepts. In the fourth section, we deal with the presentation of the

[1] The figure 1, presented in the appendix, describes the degree of financial integration for a sample of emerging markets.

methodology and data used to reach our aim. In the fifth section, we report the empirical results. The sixth and final section is reserved to the conclusion.

2. Transmission of volatility and contagion

Nowadays, the financial literature has not presented an obvious distinction between the transmission concept and the contagion concept. However, we can rely on three definitions of contagion proposed by the World Bank to distinguish between these two phenomena.

i. According to the larger definition mentioned by the Word Bank, contagion is the transmission of shocks across countries or generally the effects of inter-country propagation. The contagion may then occur in good circumstances as well as in bad circumstances. Although, it has been generally considered mainly in times of crisis.

ii. The second definition is considered restrictive. It states that contagion is the transmission of shocks between markets beyond the basic links between them, except the common shocks. This is called the co-movement in excess of these markets, which is often explained by the investor's behavior known as "*Herding Behavior*". It is due to the asymmetric information which means that the less informed investors follow those supposedly the most informed. Regarding the fundamental links between financial markets, they are divided into financial links (through the international financial relationships), real links (mainly associated with the international trade) and political links.

iii. Finally, according to the third definition, qualified by the World Bank as very restrictive, the contagion is the increase in correlations between financial markets during periods of crises compared to periods of relative stability.

The distinction between transmission and contagion according to these three definitions introduced by the World Bank depends on the qualification of the definition (broad, restrictive or very restrictive). Then, we can assign the first definition of contagion to the phenomenon of transmission and the third qualified as very restrictive by the World Bank to the phenomenon of contagion. It is generally mentioned that the literature on financial contagion has had very close links with the literature on financial crises. This is mainly due to the fact that it has often been said that financial crises appear by "packets" (a succession of crises in different markets).

3. Literature Review

Studies of volatility spillovers have attracted the attention of several authors. Indeed, many studies focused on the case of developed markets and more recently the case of emerging markets given the increase in their degree of integration after the liberalization process (Hamao et al., 1990; Karolyi, 1995; Leachman and Francis, 1996; Kearney, 2000; Bensafta and Samedo, 2011). Indeed, Hamao et al. (1990) apply a univariate GARCH methodology to analyze the relationship between international markets. These authors analyze the transmission of the daily volatility between New York, London and Tokyo stock exchanges. In particular, they find spillover of volatility from New York to London and Tokyo and from London to Tokyo. Karolyi (1995) also explores the daily data to determine the mechanism of transmission of the return and volatility between stock markets of the North American region. The author uses both a bivariate GARCH model and a vector autoregressive model (VAR) and finds that shocks from the U.S. market have more impact on the volatility of shares quoted only on the Canadian market than on the volatility of shares that are subject to a dual quotation. Aggarwal et al. (1999) use a model that combines GARCH specification with regime changes. In particular, they use the heteroscedastic ICSS algorithm of Inclan and Tiao (1994) to determine the changing points of volatility and examine the local and global events that took place. These changes are introduced as dummy variables in the variance equation of GARCH model. In their study of emerging markets, they find that most changes in volatility derive from the local factors. So et al. (1997) adopt a stochastic volatility model to study the volatility transmission of equity markets in seven Asian countries. This study provides evidence in favor of volatility transmission between financial markets in Asia. More recently, Bensafta and Semedo (2011) study the multivariate dynamics of returns of different financial markets. The conditional market returns are modeled using a constraint VAR specification while their conditional variances are modeled by a multivariate GARCH specification. The main objective of the paper is to prove the existence of multiple regimes of variance obtained by the heteroscedastic ICSS algorithm and to use this feature to correct the measurement of volatility persistence. In addition, this model allows to estimate the variance transmission and to test the no-contagion based on the stability of cross-correlations. The authors consider a sample of 11 stock market indices in Europe, North America and Asia between 1985 and 2006. Their results on the return transmission confirm the significant effect of the U.S. stock prices on those of other markets. Also, there is one-way transmission of the U.S. market volatility to the other markets. In addition, there are also regional transmissions in Europe and Asia.

The Markov switching regime technique has been widely used in the empirical literature on volatility transmission between financial markets. Generally, models with switching regime are used to analyze both the equation of average and volatility. Indeed, Edwards and Susmel (2001) apply a bivariate SWARCH model and conclude that high volatility tends to be linked to international crises. Their results show interdependence rather than contagion. Also, Edwards and Susmel (2003) use a switching regime model to analyze the volatility of interest rates in emerging markets. The SWARCH model allows researchers to locate and to date the periods of high volatility, and it is found that, in emerging markets, they tend to be similar in geographically separated regions.

The empirical studies of contagion can be divided into three groups based on the used methodology. The first one measures the propagation of shocks by the correlation between financial markets. The basic assumption is whether the spread changes the magnitude before or after crises. Studies based on this methodology are more interested in the reaction of the foreign markets to the stock market crash of 1987 in the United States (King and Wadhwani, 1990; Bertero and Mayer, 1990; Longin and Solnik, 1995; Edwards, 1998; Forbes and Rigobon, 2002; McAleer and Nam, 2005). The second group of empirical studies mainly uses ARCH/GARCH models to study the interactions between financial markets. For example, Edwards (1998) verifies if the volatility spreads to the bond markets of Argentina and Chile after the 1994 Mexican crisis. The author concludes that there is evidence of volatility spillovers from Mexico to Argentina, but not to Chile. Recently, Martinez and Ramirez (2011) analyze the spread of shocks across assets markets in eight Latin-American countries. First, authors measure the extent of markets reactions with the Principal Components Analysis (PCA). Second, they investigate the volatility of assets markets based on ARCH-GARCH models in function of the principal components retained in the first stage. Results do not support the existence of financial contagion, but of interdependence in most of the cases and a slight increase in the sensibility of markets to recent shocks. The last group of studies treats the contagion phenomenon using the correlation of returns unexplained by the model of asset pricing. As such, we can cite the study of Bekaert et al. (2005). By defining contagion as the correlation of residual returns unexplained by fundamentals (or macroeconomic and financial conditions), the authors state that they do not find evidence of contagion during the 1994 Mexican crisis, but they observe increased correlation of residual returns during the

Asian crisis of 1997. We note that in this study, the authors use data from three different regions: Europe, Southeast Asia and Latin America. Some studies have focused on determining the causes of contagion and volatility spillovers (Masson, 1999; Forbes and Rigobon, 2001; Pritsker, 2001). In general, the authors focus on two main factors: the spillover resulting from the economic and financial interdependence, such as trade links and/or financial transactions, and the irrational behavior of investors such as mimicry, lack of trust and the increase of risk aversion. In summary, financial integration could make emerging markets more dependent on the volatility of the foreign markets.

From the previous literature review, we can notice a multiplicity of methodologies used in the analysis of volatility transmission and the risk of contagion. This paper attempts to explore the dynamics of volatility spillovers between emerging markets and developed markets in normal times and in times of financial crises. The following section describes the methodology used in this study.

4. Empirical methodology and data

To test the phenomenon of volatility transmission and the risk of contagion, we apply the technique of Bai and Perron (1998, 2003) which is based on determining the dates of structural breaks. Our empirical strategy is based on identifying similarities in the dates of structural breaks between the different markets in order to test the international transmission of volatility and on comparing the occurrence dates of financial crises with the dates of structural breaks so as to verify the risk of contagion between markets.

In Monte Carlo experiments, Bai and Perron (2006) find that the method of Bai and Perron (1998, 2003) is powerful enough to detect structural breaks. For this reason, we decided to apply this method which consists in regressing the volatility indices on a constant and test the presence of structural breaks in the constant.

We consider the following regression model with *m* breaks and *m +1* regimes.

$$v_t = \beta_j + \varepsilon_t \qquad \text{with} \qquad t = T_{j-1}+1, \ldots, T_j \qquad \text{and} \qquad j = 1, \ldots, m+1 \tag{1}$$

v_t is a volatility index in period *t* and β_j (*j = 1, ..., m +1*) is the mean level of volatility index in the j_{th} regime. $T_1, \ldots, T_m$ represent structural breakpoints for various regimes (by convention $T_0 = 0$ and $T_{m+1} = T$). Bai and Perron (1998, 2003) explicitly treat these structural breakpoints as unknown, and estimates of the breakpoints are generated using the ordinary least squares method (OLS). Indeed, equation (1) is estimated by OLS regression for each T_m. β_j estimations are generated by minimizing the sum of squared residuals given by the following equation:

$$S_T(T_1,\ldots,T_m) = \sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} (v_t - \beta_i)^2 \tag{2}$$

Structural breaks are given by:

$$(T_1,\ldots,T_m) = \arg\min_{T_1,\ldots,T_M} S_T(T_1,\ldots,T_m) \tag{3}$$

In this expression, S_T is the sum of squared residuals issued from the estimation of *m* regressions in the equation (3). The selection procedure of structural breaks is based on the Bayesian Information Criteria (BIC).

To conduct this analysis, Bai and Perron (2006) impose some restrictions on the possible values of break dates. In particular, each break date must be asymptotically distinct and bounded by the borders of the sample. For this purpose, they impose different thresholds (trimming parameters) for the estimation of their model [$\varepsilon = (0.25; 0.15; 0.10; 0.05)$], with $\varepsilon = h / T$, where T is the sample size and h is the minimal permissible length of a segment. They recommend to not using a trimming parameter below 5% when taking into account the heteroskedasticity and the serial correlation. Indeed, we retain the threshold of 5% in our work.

To adopt the Bai and Perron test, we use the volatility series of nine markets, obtained by fitting a GARCH (1,1) model, including seven emerging markets (Argentina, Brazil, Chile, South Korea, India, Mexico, Thailand) and two developed markets (United States and Japan). We selected markets whose data on stock indices are available during the period from January 1976 to December 2008, so as to cover several episodes of financial crises. To compute such variables, we used the S&P/IFCG total return indices for the sample of emerging markets and the MSCI market indices for the developed ones, extracted from DATASTREAM database. We note that the choice of the GARCH model to calculate volatility has been recommended by many authors who have argued that the GARCH (1,1) model is the most appropriate model predicting volatility, given the existence of ARCH effect in the series of returns (Holden et al., 2005; Charles and Darné, 2006; Nikkinen et al., 2008; Ramlall, 2010; Ben Rejeb and Ben Salha, 2013).

Table 1 presents the descriptive statistics of monthly returns. We note that they are globally similar to the findings of previous studies. First, market returns are significantly departed from normality according to the Jarque-Bera test. Second, the study of stationary by the use of the Dickey-Fuller unit root test clearly shows that the distributions of market returns are stationary, even at the 1% confidence level, since the ADF calculated value is strictly below the critical threshold. Finally, the Engle's (1982) test for conditional heteroskedasticity rejects the null hypothesis of no ARCH effect in monthly returns. This justifies the use of the GARCH specification.

5. Empirical results

Table 2 presents the results of parameters estimation of the GARCH (1,1) model for individual markets, and makes a detailed analysis of volatility series. We note that, except Japan, the parameters of the conditional variance equation are positive and statistically significant at 1% confidence level and satisfy the conditions of theoretical stability $(\omega > 0, \alpha \geq 0 \text{ and } \beta \geq 0)$. Furthermore, the persistence of conditional volatility is verified for the majority of stock markets, since the risk premium measured by $(\alpha + \beta)$ is superior to 0.9. The diagnostic of standardized residuals presented in table 2 (part III) suggests that the GARCH(1,1) model seems to be performing to explain the variations of stock market returns since the residuals and squared residuals are not serially correlated. Moreover, we note the absence of ARCH effect among residual series. In order to compare the extent of stock markets conditional volatility, we present, in table 2 (part II) a summary of some descriptive statistics in emerging markets. At first glance, one can remark that the most volatile stock market index is observed in Argentina and Brazil. Finally, it is interesting to note that the emerging stock markets are more volatile than the developed ones.

Table 1. Basic statistics of stock markets monthly returns

	Mean	Standard deviation	Skewness	Kurtosis	Jarque-Bera	ADF Statistics	Q(6)	Q(12)
Argentina	0.936	16.526	-0.038	16.081	1968.041++	-18.610++	14.489	19.876
Brazil	0.616	15.828	-0.675	6.472	159.679++	-16.999++	3.560	11.756
Chile	1.337	7.223	-0.268	4.261	21.596++	-13.005++	16.865+	23.866
India	0.569	8.910	-0.070	3.251	0.958	-14.996++	8.321	10.785
South Korea	0.649	10.667	0.186	5.818	92.929++	-15.656++	6.055	9.444
Mexico	1.382	11.706	-2.463	18.641	3092.773++	-11.418++	33.778++	38.458++
Thailand	0.430	11.176	-0.477	5.104	61.411++	-15.365++	13.636	36.357++
Japan	0.243	6.715	0.080	3.886	9.325++	-15.756++	4.939	19.333
USA	0.511	4.574	-1.220	9.007	483.631++	-15.678++	0.923	5.790

Notes: The table presents basic statistics of monthly returns. Columns 1 to 5 are reserved to the mean (%), the st skewness, the kurtosis and the Jarque and Bera normality test statistics. Q (6) and Q (12) are statistics of the L test applied on returns with lags between 6 and 12. ARCH (6) and ARCH (12) are the statistics of the conditio proposed by Engle (1982), using the residuals of the AR (1) model. ADF is the statistics of the ADF unit root tes Fuller (1981). The ADF test is conducted without time trend or constant. + and ++ denote that the null autocorrelation, normality, no-stationarity and homogeneity) are rejected at, respectively, 5% and 1% levels. January 1976 to December 2008.

Table 2. Estimation of conditional volatility using the GARCH (1,1) model

	Argentina	Brazil	Chile	India	South Korea	Mexico	Thailand
Part I: Estimated parameters							
ω	0.000 (0.000)**	0.000 (0.000)*	0.000 (0.000)*	0.000 (0.000)	0.001 (0.000)**	0.001 (0.000)**	0.000 (0.000)**
α	0.172 (0.023)**	0.122 (0.039)**	0.020 (0.006)**	0.105 (0.031)**	0.246 (0.064)**	0.181 (0.028)**	0.231 (0.044)**
β	0.818 (0.018)**	0.861 (0.035)**	0.961 (0.007)**	0.852 (0.043)**	0.566 (0.071)**	0.759 (0.027)**	0.699 (0.049)**
$(\alpha+\beta)$	0.990	0.983	0.981	0.957	0.812	0.940	0.930
Log-likelihood	134.513	223.808	433.066	449.307	368.517	322.118	389.738
Part II: Basic statistics of conditional volatility							
Mean	0.046	0.023	0.007	0.006	0.013	0.015	0.011
Standard deviation	0.055	0.017	0.004	0.003	0.028	0.019	0.012
Minimum	0.006	0.005	0.002	0.002	0.004	0.005	0.002
Maximum	0.361	0.124	0.023	0.024	0.412	0.210	0.104
Jarque-Bera	1742.1^{++}	1345.7^{++}	141.6^{++}	893.4^{++}	226140.1^{++}	27421.5^{++}	4007.6^{++}
ADF test	-4.127^{++}	-3.534^{++}	-4.404^{++}	-3.541^{++}	-11.848^{++}	-5.889^{++}	-8.058^{+}
Q(12)	1686.9^{++}	2874.2^{++}	3856.5^{++}	1727.1^{++}	371.85^{++}	923.53^{++}	1210.2^{++}
Part III: Diagnostic of standardized residuals							
Mean	0.004	-0.011	0.017	0.012	-0.062	-0.032	0.012
Standard deviation	1.002	1.000	1.011	0.996	0.999	1.002	0.999
Minimum	-4.398	-4.250	-4.140	-2.658	-4.099	-5.172	-3.969
Maximum	5.451	2.969	3.530	3.331	4.332	2.312	4.299
Skewness	0.262	-0.366	-0.131	0.086	0.201	-1.423	-0.001
Kurtosis	6.690	4.256	3.722	3.398	4.088	7.951	4.532
Jarque-Bera	228.67^{++}	34.816^{++}	9.740^{++}	3.097	22.185^{++}	536.86^{++}	38.636^{++}
Q(12)	9.703	6.323	24.138^{+}	8.557	8.825	34.398^{++}	35.892^{++}
$Q^2(12)$	2.179	12.520	14.685	6.668	9.976	11.453	7.945
ARCH(12) test	2.512	11.790	14.196	7.048	9.414	11.168	7.486

Notes: The variance equation for the GARCH (1,1) model is written as follows: $h_t = \omega + \alpha\,\varepsilon_{t-1}^2 + \beta\,h_{t-1}$. * and ** i respectively statistically significant at 5% and 1% levels. $^{+}$ and $^{++}$ indicate that the null hypothesis of statistica normality, homogeneity and no stationary) is rejected, respectively, at 5% and 1% levels.

It is interesting to note that the previous studies on the transmission of volatility between financial markets, mainly the emerging ones, led to results justifying the presence of transmission in a unidirectional way and sometimes bidirectional. The proliferation of financial crises over the past decades, especially in emerging economies, takes our attention to a very important concept in the financial literature: the volatility transmission in times of crises (contagion). This dangerous phenomenon drew actually the attention of many researchers in the field of finance. In line with these studies, this paper analyzes the concept of contagion in a sample of emerging and developed markets. Applying the technique of Bai and Perron (1998) on the volatility series generated from the standard GARCH model gives results presented in table 3.

Table 3. Results of the Bai-Perron's test, number and date of structural breaks ($\varepsilon = 0.05$)

Argentina[(a)]	Brazil[(a)]	Chile[(a)]	India[(b)]	South Korea[(b)]	Mexico[(a)]	Thailand[(b)]	USA	Japan
6	9	8	7	3	7	6	4	8
1977:08	1982:12	1981:07	1977:08	1977:08	1982:03	1978:01	1992:04	1986:02
1984:05	1989:07	1983:02	1985:04	1997:11	1983:10	1987:09	1997:04	1988:06
1986:06	1991:04	1987:11	1992:03	1999:06	1987:06	1997:09	2003:08	1994:04
1989:07	1994:12	1991:03	1993:10		1989:01	1999:04	2007:08	1997:11
1991:02	1995:08	1994:02	2002:02		1994:12	2000:11		1999:01
1992:10	1997:11	1998:09	2007:05		1998:09	2002:03		2001:01
	1998:09	2001:10	2008:07		2002:12			2004:11
	2000:04	2008:09						2008:09
	2008:09							

Notes: [(a)] and [(b)] represent the regional affiliation of each country. [(a)] for the Latin America region and [(b)] for the Asian region.

According to table 3, we can notice that the number of structural breaks in volatility differs from one market to another. The Brazilian market is in the first position with the largest number of structural breaks (9), followed by the Japanese market. Indian and Mexican markets are in the third place with a number of structural breaks equal to 7. The Korean market knows the smallest number of structural breaks (3). This may give us an idea about the extent of volatility in these markets.

More in depth reading of these results allows us to detect the presence of volatility transmission between the markets composing our sample. It should be noted also that the impulsion effects of volatility is often not immediate, but varies in a maximum interval of three months. Moreover, it is important to invoke the effect of geographical proximity on this transmission. Indeed, in the Latin American region, we remark the existence of similarity in the dates of structural breaks. We cite, for example, the case of Argentina and Brazil (1989:07), Argentina, Brazil and Chile, whose transmission is not immediate (respectively 1991:02, 1991:04, 1991:03), Brazil, Chile and Mexico (1998:09) and Mexico and Brazil (1994:12). In the Asian region, we can also identify similarity in the dates of structural breaks between South Korea and India (1977:08), South Korea and Thailand (respectively 1997:11, 1997:09 and 1999:06, 1999:04), India and Thailand (respectively 2002:02, 2002:03). The transmission is also verified between the developed and emerging countries; for example, between Japan, Brazil, South Korea and Thailand (1997: 11).

Until now, we verified the presence of volatility transmission between the emerging markets and also between them and the developed ones. To test the existence of contagion, we try to check the transmission in times of financial crises. To do this, we report all the structural break dates and the financial crises dates. In this context, we choose the most significant financial crises during the three last decades. The results are shown in table 4.

Table 4. Comparative analysis of structural break dates with financial crises dates

Financial crises dates	Markets	Structural Break dates	Breakpoint values
Debt crisis August 1982-83	Brazil	1982 :12	0.0154
	Chile	1983 :02	0.0111
	Mexico [c]	1982 :03	0.0160
		1983 :10	0.0192
Mexican crisis December 1994-95	Mexico [c]	1994 :12	0.0085
	Brazil	1994 :12	0.0245
		1995 :08	0.0170
Asian crisis July 1997-98	Thailand [c]	1997 :09	0.0100
	Mexico	1998 :09	0.0105
	Brazil	1997 :11	0.0103
		1998 :09	0.0127
	Chile	1998 :09	0.0052
	South Korea	1997 :11	0.0078
	Japan	1997 :11	0.0043
Bubble technology crisis March 2000-01	Brazil	2000 :04	0.0228
	Chile	2001 :10	0.0034
	Thailand	2000 :11	0.0207
	USA	2001 :01	0.0025
Subprime crisis August 2007-09	USA [c]	2007 :08	0.0010
	Brazil	2008 :09	0.0119
	Chile	2008 :09	0.0031
	Japan	2008 :09	0.0035
	India	2008 :07	0.0098

Notes: [(c)] means the native country of the crisis.

First, table 4 clearly shows that several structural break dates coincide with financial crises dates. Second, we note that several points previously identified as points of transmission are identified during financial crises, which supports the presence of contagion. For the debt crisis, which mainly hits the Latin American countries between 1982 and 1983, the transmission was identified among three countries in our sample: Brazil, Chile and Mexico. During the Asian crisis of 1997-1998, several countries have shown a transmission in their volatility series given the presence of multiple structural breaks that coincide with the occurrence date of this crisis: for Thailand in which the crisis started (1997:09), Mexico (1998:09), Brazil (1997:11, 1998:09), Chile (1998:09), South Korea (1997:11) and Japan (1997:11). The transmission is also identified during the subprime crisis: USA (2007:08), Brazil (2008:09), Chile (2008:09), India (2008:07) and Japan (2008:09). These results are corroborated by several works which have shown that the proliferation of financial crises during the last decades in the emerging markets poses the problem of contagion (see for example, Bekaert et al., 2005). In fact, through our analysis of structural breaks, the contagion is verified for many times during several financial crises which characterized the emerging markets.

So far, the most frequent question for the regulators of emerging countries is: How to avoid the risk of contagion? In fact, many studies have tried to answer this question such as Masson (1999) and Forbes and Rigobon (2001). The financial liberalization is considered as a generator of financial crises (Ranciere et al., 2006; Eichengreen and Arteta, 2000; Dell' Ariccia et al., 2012). Generally, the application of a financial liberalization process requires a robust financial infrastructure and must be accompanied with preventive measures against the fragility of the financial system and the proliferation of financial crises (Ben Salha et al., 2012). Given the high fragility of the financial systems in emerging countries, it is necessary to rationalize their openness to the rest of world in order to reduce the occurrence of financial crises and consequently the risk of contagion. More precisely, they must adopt a gradual financial liberalization process and must undertake some reforms related to the exchange rate regimes and the interest rates, in order to avoid the high devaluation of the national currency which is generally at the origin of financial crises (Nguyen, 2005). We note also that the international cooperation is generally considered as another way to predict and avoid the risk of crises and contagion resulting from international fluctuations. This suggests that emerging countries have to take part in regional and international blocks (World Bank and FMI), which aim is to make coordination between them and to establish common prudential rules.

6. Conclusion

The principal objective of our paper is to test the international transmission of volatility and the risk of contagion using a methodology based on the determination of structural breakpoints. Consequently, the test introduced by Bai and Perron (1998, 2003) is adopted. In this context, it is crucial to note that this methodology has been rarely used. Our empirical results manifest interesting conclusions. First, the transmission of volatility is effective inside emerging markets, and between them and the developed ones. For instance, we find an analogy between the dates of structural breaks throughout the different markets manifested in our sample. Second, we show that the geographic proximity has an important effect on transmission. Finally, a comparison between the occurrence dates of financial crises and the dates of structural breaks allows us to deduct the existence of high analogy between these two types of dates. This situation confirms that financial shocks may be transferred from one market to another during financial crises periods.

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Appendix

In the financial literature, we can identify several methods that quantify the degree of financial integration. Among them, we mention the method introduced by Bekaert (1995), which equates the degree of financial integration to the ratio of foreign investors' accessibility to the domestic markets, measured by the market capitalization available to foreign investors divided by the total domestic market capitalization. Indeed, we use this ratio for a sample of emerging countries, for which we have already gathered the necessary data: the market capitalization of both S&P/IFCI index represents the fraction of the domestic market available to foreign investors and S&P/IFCG index represents the total capitalization of the domestic market. Figure 1 represents the evolution of the degree of financial integration among five emerging countries (Argentina, Brazil, Chile, Mexico, and Thailand) during the period between January 1989 and December 2008.

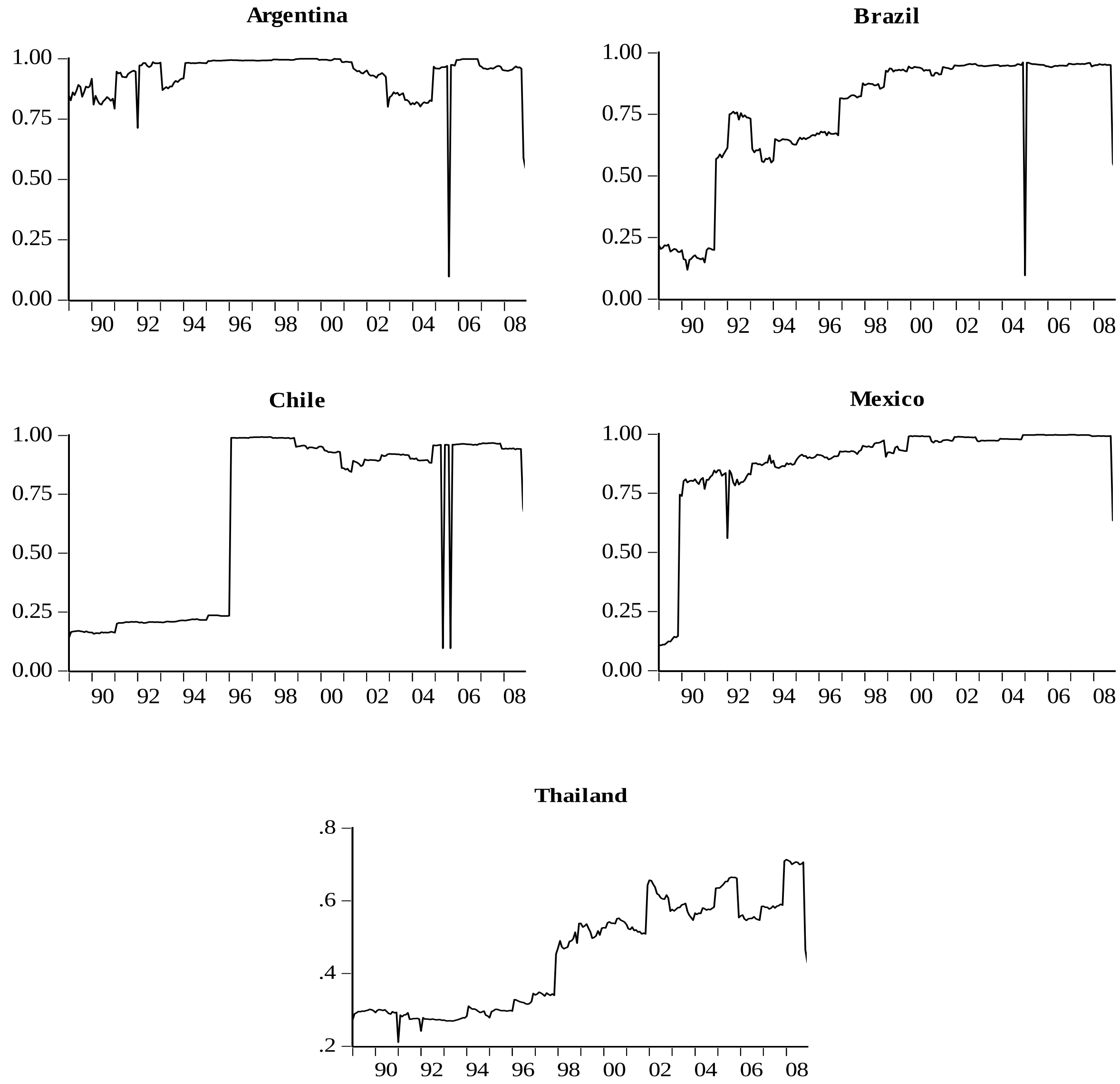

Figure 1. Evolution of the degree of financial integration

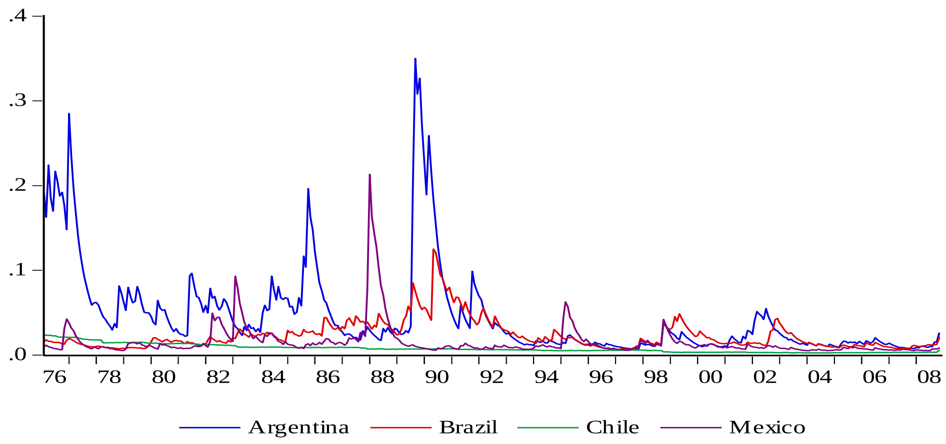

Figure 2. Volatility dynamics in Latin American markets

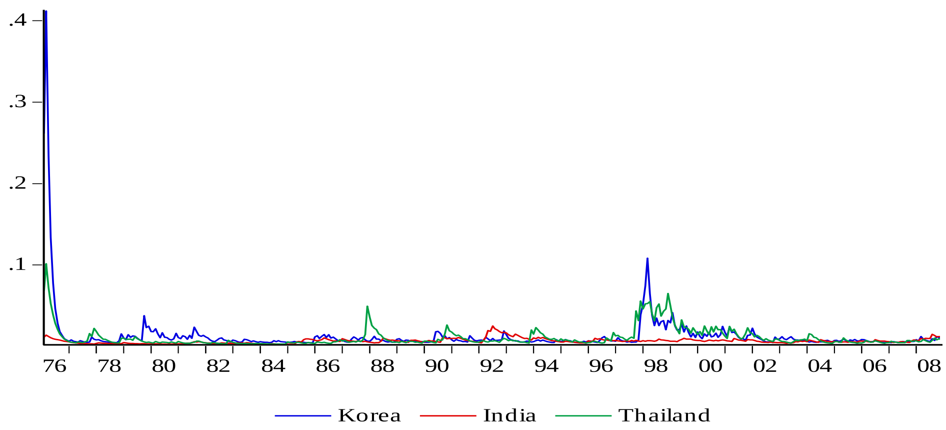

Figure 3. Volatility dynamics in Asian markets

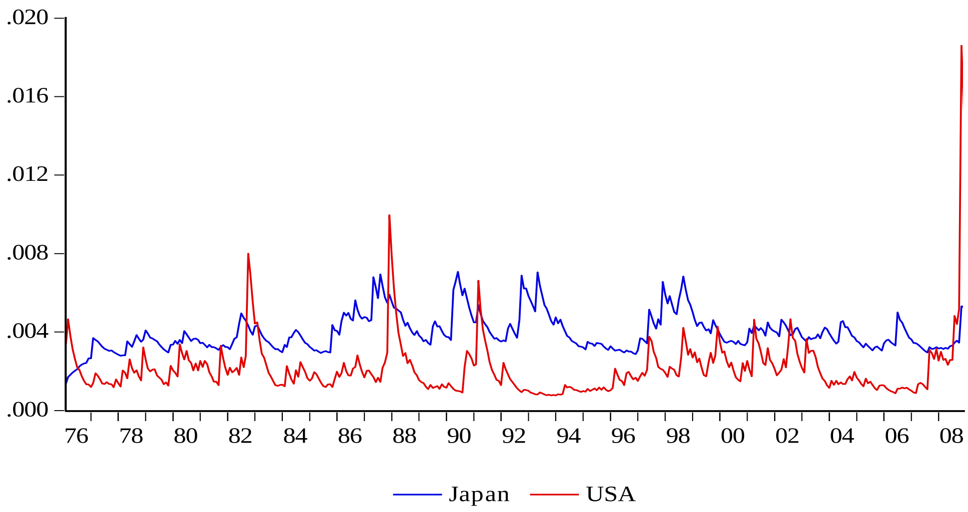

Figure 4. Volatility dynamics in developed markets