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Ben Rejeb, Aymen and Boughrara, Adel

Faculty of Economics and Management of Mahdia, University of Monastir, Tunisia and Laboratory of Management of Innovation and Sustainable Development, University of Sousse, Tunisia, Faculty of Economics and Management of Sousse, University of Sousse, Tunisia

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Aymen Ben Rejeb [a, b, *] **and** **Adel Boughrara** [c]

[a] Faculty of Economics and Management of Mahdia, University of Monastir, Tunisia
[b] Laboratory of Management of Innovation and Sustainable Development, University of Sousse, Tunisia
[c] Faculty of Economics and Management of Sousse, University of Sousse, Tunisia

Abstract

The purpose of this paper is to examine the volatility relationship that exists between emerging and developed markets in normal times and in times of financial crises. The Vector Autoregressive methodology and the Bai and Perron (2003a,b)'s technique are used. The paper results lead to very interesting conclusions. First, it has been found that volatility spillovers are effective across financial markets. Second, it has been proven that geographical proximity is of great importance in amplifying the volatility transmission. Finally, it has been shown that financial liberalization contributes significantly in amplifying the international transmission of volatility and the risk of contagion.

Keywords: stock market volatility; volatility spillover; financial liberalization; financial crises; emerging stock markets;

JEL Classifications: F3, G01, G15, G18, C58

[*] Corresponding author (telephone number: +21697310188, fax number: +21673210515).
E-mail addresses: benredjeb_aymen@yahoo.fr (A. Ben Rejeb), adel.boughrar@fdseps.rnu.tn (A. Boughrara).

1. Introduction

Since its implementation by developed countries, financial liberalization has set as its main objective the strengthening of financial integration in order to reap its benefits (risk diversification, reduction of cost of capital, informational efficiency). These benefits will help to strengthen economic growth (Chari and Henry, 2004; Mckinnon, 1993; Mckinnon, 1973). The implementation of such policy in emerging markets leads to several consequences. Several previous studies have shown, for example, that financial liberalization tends to reduce volatility and improve the level of informational efficiency in emerging markets (Ben Rejeb and Boughrara, 2014; Ben Rejeb and Boughrara, 2013; Nguyen, 2010; Kassimatis, 2002; Kim and Singal, 2000; Bekaert and Harvey, 1997). It is therefore clear that financial liberalization has an important role in improving the financial situation of emerging markets and consequently their economic growth. However, despite its many advantages, no one is unaware that in the short term, financial liberalization is often accompanied by a wave of financial crises, many of which have taken a systemic extent and hit, in particular, the newly liberalized economies. Some studies show that strengthening financial integration as a main objective of financial liberalization, obtained through the progressive abolition of various barriers to international investment as well as the elimination of capital mobility restrictions which was essentially responsible of emerging markets financial turbulences (See among others, Ranciere et al., 2006; Dell'Ariccia et al., 2005; Eichengreen and Arteta, 2000; Kaminsky and Reinhart, 1999). According to these studies, the success of this goal depends heavily on each country's economic conditions at the opening of its market.

The chief concept that has attracted much researchers' attention in recent years is the volatility transmission (spillover) subsequent to the rapid integration of financial markets. The results of their research indicate the existence of unidirectional, and sometimes, bidirectional spillovers between international stock markets (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 emerging economies, the financial literature has concentrated on studying the volatility transmission in times of crises (contagion) and especially on understanding and identifying the transmission mechanisms (Bekaert et al., 2005; Forbes and Rigobon, 2002, 2001; Pritsker, 2000; Masson, 1999).

This paper aims to study the interdependencies in terms of stock market volatility between financial markets (emerging and developed) and to test the impact of financial liberalization on these interdependencies. The empirical methodology this paper uses is based on two main econometric models. Firstly, it makes use of VAR model, combined with a standard GARCH model in order to analyze the causal relationships in terms of volatility across stock markets. The analysis of the impulse response functions (IRFs) and the forecast errors variance decompositions (FEVDs) permit also to capture, more specifically, the volatility interdependencies pattern (magnitude, speed...). To assess the potential of financial liberalization impact on these interdependencies, we implement a completely different strategy compared to previous studies that have dealt with this topic by simply comparing the volatility interdependencies over two sub-periods, before and after the financial liberalization. We do believe that previous studies have ignored the evolutionary and gradual character of financial liberalization, as they have not considered a very important phase in this process, namely the maturity phase where countries have completed the financial liberalization process implementation and become more mature. We therefore adopt a strategy which is based on the comparison of the interdependencies on three phases. The third phase is characterized by the maturation of the markets. The rationale behind using this strategy is that financial liberalization, as a newborn process, can contribute to strengthening the interdependencies depending on the markets integration degree, we then think to identify the persistence of these interdependencies after the implementation of financial liberalization process.

Secondly, we adopt a more suitable econometric technique in the context of stock markets, which are generally characterized by the presence of multiple regimes in the variance (Bensafta and Semedo, 2011; Nguyen, 2008). This technique, which is rarely used, was developed by Bai and Perron (1998, 2003a,b), and it is based on the determination of structural breaks. It is a two-stage procedure. During the first stage, the international transmission of volatility is assessed, by dating and identifying similarities in the structural breaks. During the second stage, the risk of contagion is tested by comparing the occurrence dates of financial crises with the structural break dates.

The present paper is organized as follows: Section 2 presents a concise literature survey on volatility transmission and contagion risk. Section 3 presents the methodology and the data used. Section 4 reports the estimation results of the VAR model and the various corresponding tests in a first sub-section. The results of the structural break points technique are reported in a second sub-section. Section 5 discusses economic policies implications. Section 6 concludes.

2. Literature review

Volatility spillovers have been an issue of increasing interest for a long time. A large strand of empirical finance has focused on the case of developed markets, and recently on the case of emerging markets owing to their degree of integration increase subsequent to the liberalization process (Bensafta and Samedo, 2011; Kearney, 2000; Leachman and Francis, 1996; Karolyi, 1995; Hamao et al., 1990). The empirical financial literature shows that there a wide range of statistical and econometric models used to analyze the interdependencies between financial markets. The most important of them are cross-correlations models, VAR models, co-integration models, conditional variance models, regime-switching models and stochastic volatility (SV) models. In the following, we present an overview of literature on the pioneer studies dealing with this subject by reference to these models.

Since the introduction of conditional variance models, several ARCH/GARCH specifications have been widely used in studies investigating the relationship between financial markets and especially in those analyzing international volatility transmissions. Hamao et al. (1990) make use of the univariate GARCH model to analyze the relationship in terms of volatility across international markets. They explore the transmission of daily volatility between stock markets in New York, London and Tokyo by using a two-step approach. Authors can determine using this methodology if there is a relationship between domestic market volatility and those of foreign markets. In particular, they lead to a spillover of volatility from New York to London and Tokyo and from London to Tokyo. The authors come to the conclusion that the effect of financial integration appears more significant on the transmission of mean than on the transmission of variance.

Karolyi (1995) also explores the daily data to determine the transmission mechanism of the return and volatility between equity markets of the North American region. The author uses both a VAR model and a bivariate GARCH model, and finds that shocks from the U.S. market have more impact on shares quoted volatility only for the Canadian market compared with the volatility of shares that are subject to a dual quotation. He also shows that the importance of shocks increases with the increase of different types of market linkages.

Li (2007) examines the volatility relationships possibly existing between two emerging stock markets (mainland China and Hong Kong) and the United States market. The author uses a multivariate GARCH model identical to the BEKK approach developed by Engle and Kroner (1995) in order to account for the regularities which characterize the stock indices.

Results show evidence of unidirectional transmission of volatility from Hong Kong stock market to those of Shanghai and Shenzhen. However, no linkage was found between stock markets in the mainland China and the United States. In addition, a weak dependence between volatility in the Hong Kong and the China markets is verified. The author attributes this weak dependency to the weak degree of market integration.

Darrat and Benkato (2003) analyzes, using a GARCH model and a multivariate co-integration tests, the linkages of return and volatility between the Istanbul Stock Exchange (ISE) and the world market represented by the stock markets of the United States, United Kingdom, Japan and Germany. Results suggest that the ISE has become significantly integrated into the global market after the introduction of liberalization towards the end of 1989. Results further show that the USA market and the UK market are the principal sources of volatility spillovers for the ISE. Aggarwal et al. (1999) use a model that combines GARCH specification with regime switching. In particular, they use the heteroscedastic ICSS algorithm of Inclan and Tiao (1994) to identify the turning points of volatility and examine the local and global events that took place. These changes are accounted for by including dummy variables in the equation variance of the GARCH model. Results suggest that for emerging markets, the most changes in volatility derive from local factors.

More recently, Bensafta and Semedo (2011) study the multivariate dynamics of returns for various national financial markets. Conditional mean of market returns are modeled using a VAR specification while their conditional variances are modeled by a multivariate GARCH specification. The main objective of this study is to show the existence of multiple regimes in the variance. In addition, this model estimates transmissions variance and test 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 mean transmission confirm the significant effect of American stock prices on stock prices of other markets. They also show that there is almost unidirectional transmission of volatility from the American market to other markets. There exist also regional transmissions in Europe and Asia. Better still, Bensafta and Semedo (2011) argue that the acceleration of the stock markets interdependence is not a sideline to the financial liberalization process introduced in the 90s.

The SV models are another alternative for analyzing volatility transmission between financial markets. However, these models have not been as popular as GARCH models even though some studies have affirmed the relevance of this type of modeling when it comes to detecting interdependencies across markets. For instance So et al. (1997) employ the SV model to study the volatility transmission between equity markets in seven Asian countries. This study provides evidence in favor of volatility transmission between financial markets in Asia. Likewise, Wongswan (2006) applies the SV model for high-frequency data of the following stock markets returns: USA, Japan, Korea and Thailand. In particular, he studies the effect of macroeconomic announcements in the United States and Japan on volatility and trading volume in Korea and Thailand. This paper provides evidence of information transmission from the U.S. and Japan to Korean and Thai equity markets during the period from 1995 through 2000. In the same vein, Lopes and Migon (2002) combine the factorial models with SV models. They analyze the dependence between stock market indices in Latin America and USA. They argue that multivariate SV models may be the solution to dimensionality problems.

Finally, the Markov switching regime technique has been widely used in the empirical literature on volatility transmission between financial markets. By and large, models with switching regime are used to analyze both the equation of mean 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. Likewise, Edwards and Susmel (2003) use a switching regime model to analyze interest rates volatility in emerging markets. The SWARCH model allows researchers to date and identify the periods of high volatility. The authors come to the conclusion that the transmission of volatility in emerging markets, tend to be similar in geographically separated regions.

The empirical studies of contagion can be divided into three groups according to the methodology used[1]. The first group 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 foreign markets to the stock market crash of 1987 in the United States (McAleer and Nam, 2005; Forbes and Rigobon, 2002; Edwards, 1998; Longin and Solnik, 1995; King and Wadhwani, 1990; Bertero and Mayer, 1990). The second group mainly uses ARCH/GARCH models to study the interactions across financial markets. For example, Edwards (1998) checks whether 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

[1] Contagion, as defined by the World Bank, is the transmission of shocks in times of financial crises.

spread of shocks across assets markets in eight Latin-American countries. The authors measure the extent of markets reactions with the Principal Components Analysis (PCA), and they investigate the volatility of assets markets based on ARCH/GARCH models. Their results do not lend support to the hypothesis of financial contagion, but they rather show 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 assert that they do not find evidence of contagion during the 1994 Mexican crisis, but they argue the existence of increased correlation in residual returns during the 1997 Asian crisis. It is worth noting that in this study, the authors use data from three different regions, namely Europe, Southeast Asia and Latin America. Some studies have focused on determining the causes of contagion and volatility spillovers (Forbes and Rigobon, 2001; Pritsker, 2000; Masson, 1999). In general, the authors focus on two main factors: the spillover resulting from the economic and financial interdependence, such as trade linkages and/or financial transactions, and the irrational behavior of investors such as mimicry, lack of trust and the increase of risk aversion. In sum, financial integration could make emerging markets more dependent on foreign markets volatility.

From the previous literature review, one may notice a multiplicity of methodologies used in the analysis of volatility transmission and risk of contagion. This paper attempts to explore the dynamics of volatility spillovers (transmission and contagion) 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.

3. Empirical methodology and statistical data

In this section we present first the methodologies adopted to study the phenomena of volatility transmission and contagion and secondly we present the data used for these purposes. We advance that the use of the VAR model is designed to analyze the international transmission of volatility and to determine the impact of financial liberalization on this transmission. We are mainly based on the Granger non-causality test. The test of Bai and Perron (2003a,b) is used not only to test the contagion, but also to analyze the transmission in terms of volatility between stock markets. This will allow us to better highlight the results obtained using the VAR model.

3.1. VAR modeling

The financial and economic literature has long been interested in the study of the market interdependencies around the world. Several methodologies have been adopted for this purpose, and especially following the severe financial turbulences in the 70s, the most important are the oil shocks of 1973 and 1979. However, these methodologies have shown several limitations to the extent that they were unable to predict correctly the triggering of these crises. In a hope to fill the limits of macro-econometric models previously proposed, Sims (1980) provided the VAR methodology.

Many financial studies have shown the relevance of the VAR model in the study of the dynamic interactions between multiple variables (Diebold and Yilmaz, 2009; Cheol and Sangdal, 1989). The VAR constitutes a system of equations in which each variable depends on its own past values and those of other variables. It has the advantage of being both simple and dynamic. Its simplicity is due to the fact that it imposes few restrictions, except those regarding the choice of the selected variables and the number of lags. In addition, under certain technical conditions (absence of cross-restrictions between the disturbance terms and relative to the variance-covariance matrix) each equation of the system can be estimated individually by OLS, which would be simple to perform. In terms of its dynamic character, it has the capacity to capture and measure the interaction between several variables. These features are of particular interest in our study. Moreover, our choice of using a VAR model to analyze the transmission of volatility between stock markets is largely based on these two features of the VAR model.

Generally, the vector autoregressive model of order p (VAR (p)) can be formulated in the following manner:

$$X_t = \alpha + \phi_1 X_{t-1} + \phi_2 X_{t-2} + \ldots + \phi_p X_{t-p} + U_t \qquad \text{(Eq.1)}$$

Or equivalently:

$$X_t = \alpha + \sum_{j=1}^{p} \phi_j X_{t-j} + U_t \qquad \text{(Eq.2)}$$

Where X_t is the $(nx1)$ vector of endogenous variables, representing in our work the vector of volatility series for all markets in our sample and X_{t-j} is the vector of endogenous variables lagged j periods, p represent the optimal number of lags. t represents the time index.

α is a (*nx1*) vector of the deterministic component. ϕ_j represents the coefficients matrix of dimension (*nxn*) to be estimated. It provides information on the causal linkages between variables in *X*. U_t is a (*nx1*) vector of innovations. The innovations contained in this vector of shocks correspond to the unexplained parts of *X*. They can be correlated with each other to a given instant, but are not autocorrelated in time. In formal terms: $E(U_t) = 0$ and $E(U_t U_t^{'}) = \Omega$, with Ω is a (*nxn*) symmetric matrix of variance-covariance, definite positive. This term can contain non-zero values, other than on its diagonal. We also have: $E(U_t U_s^{'}) = 0 \; for \; t \neq s$.

It should be noted that given the generalization of the VAR model to the multivariate case, a moving average representation is designed for this purpose. The representation of the VAR model with *p* number of lags in the moving average form is then of the following form:

$$X_t = \alpha_t \theta + \sum_{j=0}^{\infty} \Theta_j U_{t-j} \qquad \text{(Eq.3)}$$

In this expression $\alpha_t \theta$ represents the deterministic component for X_t. The advantage of this representation compared to the traditional one (Eq. 2) is that we can consider the influence of the innovations on the endogenous variables. Indeed, Θ_j includes the elements measuring the effects of innovations associated with X_t.

3.2. Bai and Perron structural break technique

To assess the risk of financial contagion and to get a clear picture of volatility transmission, we have recourse to the Bai and Perron (1998, 2003a,b) technique which is based on dating the potential structural breaks. More specifically, this empirical strategy permits to appraise the risk of contagion between markets through analyzing the international transmission of volatility. This is done by comparing the occurrence dates of crises with the dates of structural breaks.

It is worth reminding that Bai and Perron (2006) find, using Monte Carlo experiments, that the method of Bai and Perron (1998, 2003a,b) is enough powerful to detect structural breaks. For this reason, we decided to implement this method, which consists in regressing the volatility indices on a constant and then testing for the presence of structural breaks in the constant.

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

$$v_t = \beta_j + \varepsilon_t \qquad \text{with} \qquad t = T_{j-1}+1, ..., T_j \qquad \text{and} \qquad j = 1, ..., m+1 \qquad \text{(Eq. 4)}$$

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

$$S_T(T_1,...,T_m) = \sum_{i=1}^{m+1} \sum_{t=T_{i-1}+1}^{T_i} (v_t - \beta_i)^2 \qquad \text{(Eq.5)}$$

Structural breaks are therefore given by:

$$(T_1,...,T_m) = \arg\min_{T_1,...,T_M} S_T(T_1,...,T_m) \qquad \text{(Eq. 6)}$$

In this expression, S_T is the sum of squared residuals issued from the estimation of m regressions in the equation (Eq.4). The selection procedure of structural breaks is based on the Bayesian Information Criteria (BIC).

To carry out this analysis, Bai and Perron (2006) assign 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 not using a trimming parameter below 5% when taking into account the heteroskedasticity and the serial correlation. Following this, the 5% threshold is retained in our study.

3.3. Descriptive data analysis

With the aim to study two of the most important phenomena on the financial seine, namely the transmission of volatility and contagion, we use the series of volatility of nine markets including seven emerging countries (Argentina, Brazil, Chile, South Korea, India, Mexico, Thailand) and two developed countries (the United States and Japan) obtained by fitting a standard GARCH(1,1) model. 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.

It should be noted that to determine the impact of financial liberalization on the volatility transmission, only markets for which data are symmetrically available before and after liberalization are considered. Besides, the adoption of the VAR methodology imposes some restrictions on the study period. The homogeneity of the start dates of the volatility series is a major limitation. For these reasons, we should be noted that only the developed and emerging markets for which data are available from January 1976 to December 2008 are retained.

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 stationarity 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.

4. Empirical results

4.1. Results of GARCH model

In this study, we use the standard GARCH(1,1) model to measure the conditional volatility for all markets in our sample. The rationale behind the use of the GARCH specification could be explained as follows. Firstly, the GARCH(1,1) specification has proven to be the most suitable especially when it comes to assessing and predicting volatility given the existence of ARCH effect in returns series (Ramlall, 2010; Nikkinen et al. 2008; Charles and Darne, 2006; Bollerslev et al., 1994). Secondly, the choice of the GARCH specification is made after a comparison with a non-linear EGARCH specification. The criteria used to determine the performance include the information criteria of Akaike and Schwarz and the log-likelihood value comparison. Results show a strong relevance of the standard GARCH compared to the EGARCH[2].

Table 2 depicts the results of parameters estimation of the GARCH(1,1) specification for individual markets and makes a detailed analysis of volatility series. We note that, except

[2] For the sake of concision, the test results are not reported here. They are available upon request from the corresponding author.

Japan, the parameters of the conditional variance equation are positive and statistically significant at 1% risk level and satisfy the theoretical stability conditions $(\omega > 0, \alpha \geq 0 \text{ and } \beta \geq 0)$. 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 inspection of the standardized residuals reported in table 2 (panel III) suggests that the GARCH(1,1) model seems to be able to explain in a satisfactory fashion the variations of stock market returns since the residuals and their squared values turn out to be not serially correlated. Moreover, there are no ARCH effects in the residual series. In order to compare the extent of stock markets conditional volatility, a summary of some descriptive statistics in emerging markets is depicted in Table 2 (panel II). At first glance, one may 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.

4.2. Results of VAR(2) and the Granger non-causality test

This section deals with the transmission of volatility between emerging and developed markets. In what follows, we provide the results of the VAR(2) model[3] and the Granger non-causality test.

It stands out from Table 3 that the VAR(2) model is able to describe and evaluate suitably, the interdependence between volatility series. Indeed, the explanatory power of the explanatory variables is generally high, and the adjusted R^2 coefficients vary from 58.9% for the American volatility equation to 99.6% for the Chilean volatility equation indicating that the model fits the data quite well. It is worth noting that the explanatory power of the volatility equations in emerging markets is higher than that in developed ones.

The results of a Granger non-causality test presented in Table 4 show a strong interdependence in terms of volatility between the markets in our sample. Indeed, 23 significant causal linkages are identified among the 90 (10*9) linkages possibly existing between emerging and developed markets. This interdependence is significant of a volatility transmission between markets. The inspection of the volatility equation results of the Argentinean market indicates that the market is Granger caused by the Chilean, the Korean and the Japanese markets. However, the volatility of the Argentinean market causes the Brazilian, the Thai and the Japanese ones. Moreover, the volatility of the Thai market is

[3] For the choice of the number of lags to be retained in the VAR model, we used the information criteria of Akaike and Schwarz and the log-likelihood value comparison and we finally tested the stability of our model.

significantly influenced by those of the Argentinean, the Chilean, the Korean and the Japanese markets.

In the light of our empirical results, we can clearly understand a strong interdependence in terms of volatility between emerging markets. Similarly, the regional transmission is effective, she has been proven in the two geographical zones to which belong the whole of our emerging countries. For example, in Latin America, the transmission is effective from Argentina to Brazil, from Chile to Argentina and from Mexico to Chile, while for the Asian region, the transmission is checked between Thailand and South Korea. These multilateral causal linkages are explained in large part by the geographical proximity (Bekaert et al., 2005). It is also important to mention the significant impact of the Japanese market volatility on those of several emerging countries. The volatility of this market causes, in the Granger sense, the volatility in other emerging markets, excluding Chilean and Indian markets.

Impulse response functions analyses

The Granger non-causality test has shown the existence of several causal linkages between the various stock markets' volatility. The results of this test probably assume that a dynamic interaction exists between the trading places to the extent that each market could react to a shock on another market. The question now is what would be the magnitude of responses to shocks and how long a market needs to dampen down the effect of a random shock.

We report in Table 5 the impulse response functions for the first, second, sixth, twelfth and twenty-fourth periods. There are several conclusions that can be drawn from these results concerning various markets volatility responses subsequent to unanticipated shocks that hit the other stock markets' volatilities as well as the magnitude and the direction of these responses. Generally, we remark that the impulses associated with each innovation have consistent influences on the volatility of individual markets. Volatility spillovers may amplify volatility in some markets and to curtail it in other markets. We also note that emerging markets react to shocks coming from both emerging and developed markets; however, the most important responses are often attributed to shocks coming from emerging markets. It is also important to note that the turbulences in the emerging markets volatility peak their highest level when it comes to shock coming from emerging markets belonging to the same region. Besides, the impulse responses of most markets to the emerging markets volatility start to pick up from the second period. This implies that the volatility reactions to shocks occurring in a specific market are far from being immediate.

It seems essential now to analyze individual effects relating to each market. For this purpose, we split the sample of emerging economies into two regions. This will help us to appraise the role of geographical proximity in the transmission of volatility shocks from one market to another. We note that for the Latin American region, a shock in the volatility of the Argentinean market seems to have substantial effects on the volatility of other markets belonging in the same region. See for example, a shock of about 1.844% in this market at the first period leads to a perturbation at a second period in the order of 0.224% in the Brazilian market, 0.053% in the Chilean market and 0.062% in the Mexican market. The effect on the other emerging markets remains of a less important magnitude, while for developed markets the effect seems more important at 6^{th} and 12^{th} horizons. It should be noted that after one year, the influence of the volatility movements of the Argentinean market on volatility of South Korean, Mexican, Thai, and Japanese markets becomes negative. Likewise, the volatility impulses responses of the Brazilian market induce significant reactions in other markets in the system, especially markets belonging to the same region as well as developed markets. Thus, a change in the volatility of about 0.577% in the Brazilian market at the first period leads to an increase in the Chilean market volatility of about 0.004% during the second period and to an instantaneous increase in the Argentinean market volatility of about 0.076%. However, the Mexican market exhibits a negative and generally small variation. As for the other markets, the reactions seem to have a smaller magnitude, except for Japanese market (0.158%). As regards the shocks related to the Mexican market, the reactions of foreign markets are more or less important than those observed following the shocks on the Argentinean and Brazilian market. However, it is important to mention the instantaneity of these reactions, except for Thailand and the developed countries where events occurred starting from the second period and whose magnitude is of a remarkable importance. Indeed, following a shock of about 0.804% in Mexico, Thailand volatility reacts of about 0.258%. Finish with the Chilean market where the reactions are instantaneous just for Argentina and Brazil. Moreover, it is clear that the magnitude of reaction is very small. This is quite understandable, since the shock in this market is also small (0.028%).

Regarding the Asian region, we have reached to the same conclusions as for the Latin American region. However, individual analysis seems more relevant. Let us start with the South Korean market that represents a market with the most important shock in the region (0.480%). Results show that the structural shock affecting the volatility of this market does not trigger any immediate effect on five markets (Indian, Mexican, Thai, Japanese and

American). But, it is clear that the reaction of Thai market from the second period has a higher magnitude when compared with the other markets (in the order of 0.159% at the 6th period). As for the other markets, the consequences of the shock seem to be instantaneous whose largest magnitude is attributed to Argentina (-0.017%) and Brazil (-0.010%). The Thai market seems to have an instantaneous impact on the Argentinean, Brazilian, Chilean, South Korean, Indian and Mexican markets. The largest magnitude accounts for Korea (0.096%), Mexico (0.069%) and India (0.023%). The response of the Japanese market volatility is more important than other markets, but it appears only from the sixth period (0.109%). Indian market in a third position after South Korean and Thai markets with a shock of about 0.109% seems to have instantaneous effects on the Argentinean, Brazilian, Chilean and South Korean markets, respectively, by 0.001%, 0.003%, -0.0009% and 0.008 %. For the other markets the responses begins from the second period with the largest magnitude is attributed to Thai market followed by the American market and the Mexican market. Finally, we find that the impulse responses on the American market are generally small. The most significant responses are attributed respectively to Chile and Mexico. The absence of significant impulsions following the structural shock of the American market could mean that the volatility of this market does not determine the volatility of other markets in the system. As for the Japanese market, we find that its impulses responses generally cause significant reactions in emerging markets. The most significant responses are attributed, respectively, to South Korea (0.051%), Brazil (0.042%), Chile (0.041%) and Argentina (-0.030%). This is an evidence of interdependence in volatility between emerging markets and Japanese market.

Analysis of the decomposition of the forecast error variance

So far we have shown, through the analysis of IRFs, that a shock on a stock market causes many disturbances on the volatility of this market and the other markets. However, in limiting ourselves simply to IRFs, we will not be able to assess the ability of each stock market to generate on the one hand its own fluctuations and on the other hand the fluctuations from other markets. We then complete the analysis of IRFs by performing a forecast error variance decomposition (FEVD). The FEVD is a technique that can measure for a given market and over a given period, the proportion of the forecast error variance of the volatility, which is explained by the innovations of another market. Thus, for each series of volatility, we perform this calculation while considering an horizon of 24-month. Table 6 reports the results of the FEVD. The inspection of these results show that in the short term, changes in stock returns in emerging and developed markets is subject to their own innovations and that the importance of foreign markets on the change in return on other markets progresses on longer time horizons (24 periods). It is equally important to note that geographical proximity plays a major role in strengthening volatility dependencies. Note also that the volatility in developed markets represented by the United States and Japan is crucial, in the most cases, for the variability of stock returns in emerging markets. In contrast, developed markets remain not very sensitive to the volatility of emerging markets on all time horizons.

An individual analysis of the FEVD (country by country), seems necessary while focusing on regional affiliation. Starting with Latin American region, we note that for the Argentinean market the influences of impulses provided by foreign markets appear to be insignificant, except for the Brazilian and Japanese markets and to a lesser extent for the Chilean and American markets. We can remark that Brazilian market as the most important source of volatility vis-à-vis the Argentinean market, on all time horizons, provides of about 8.448% and 9.697% of the forecast error variance, respectively, for the horizon of 12 and 24 months. The Brazilian market seems more influenced by the impulses of the Argentinean, Japanese, American and relatively Chilean markets. Indeed, over a period of 6 and 12 months Argentinean market provides, respectively, 4.477% and 9.534% of the forecast error variance, followed by Japanese market (7.134% on the horizon of 6 months) and the American market (2.266%). It is important to point out that over a longer horizon (24 months) the American market begins to exert influence more and more important (21,683%). When the volatility of the Chilean market starts to be substantially dependent to the impulses of foreign markets and especially developed ones, dice the 6th period. At a time horizon of 24 months, the proportion of the forecast error variance attributed to foreign markets rises nearly 31% of which 18.197% is due to the impulses coming from the United States, 2.845% from Japan, 7.989% from Thailand and 1.234% from Argentina. The impulses resulting from structural shocks of the other markets have an impact of small magnitude, see negligible. Finally, it is important to highlight the mean dependence in terms of volatility between Mexico, Chile and India. Same findings as previous, the volatility impulses in developed markets have significant impacts on the volatility of Mexico. For the same horizon (24 periods) American market contributes nearly to 43% to the forecast errors variance of the Mexican market.

We are interested now in countries belonging the Asian region. We argued that the volatility of South Korean market has become increasingly dependent on other markets innovations during the 12th period. Thai market, in the first position, provides of about 24,769% of the forecast error, American and Japanese markets in the second position accounts for, respectively, 23.057% and 7.626% of the forecast error of South Korea. Regarding the Indian market, the proportion of the forecast error variance of this market attributable to foreign markets amounts to 25,093%, of which the most significant proportion is attributed to the Brazilian market (13,938%) and, to less extent, to the American market (3.647%). Finally, it is worth noting that, in general, random changes in Thai market volatility are largely explained by their own impulses. Innovations in foreign markets explain nearly 30% of the forecast errors variance of the local volatility of which 12,852% is allocated to the Japanese market, 5.112% accounts for the American market, 3.339% is assigned for the Mexican market and 3.060% is given for the Indian market.

As for the developed markets, we find that their volatilities are moderately influenced by innovations in the emerging markets. Regarding the American market, it is clear that for a longer time horizon (24 periods), nearly 17% of the forecast error is attributable to innovations in emerging markets, of which the largest magnitude is provided by the Chilean market (8.965%) and Indian market (5.064%). Finally, it appears that the Japanese market volatility is largely affected by the innovations in the Brazilian market (11.025%) and the Indian market (11.630%).

4.3. Impact of financial liberalization on volatility transmission

We have shown in the previous section the existence of a high volatility transmission between emerging markets. We have established that geographical proximity plays a significant role in amplifying transmission because several volatility spillovers effects have been identified between emerging markets belonging to the same region.

Some studies show that the strengthening of financial integration following the financial liberalization process, which has been mostly characterized by phasing out various barriers to international investment, was particularly responsible of several financial turbulences. Bekaert and Harvey (1995), Phylaktis and Ravazzolo (2002) and Carrieri et al. (2007) show that financial liberalization has made financial markets more integrated into global international financial movements, and therefore more sensitive to external shocks. Other studies show that the propagation of volatility is the consequence of financial interdependence between stock markets (Calvo and Reinhart, 1996). It is important at this stage to ask the question on the impact of financial liberalization on the transmission of volatility in emerging markets.

In this section, we analyze the impact of financial liberalization on volatility transmission. It is important however to remind that most previous studies which have dealt with this subject have made comparison of the volatility interdependencies over two sub-periods. The first one is before financial liberalization and the other after. See, for example, Nguyen (2005) who has chosen the month of September 1989 to decompose into two sub-periods (before and after financial liberalization) of the fact that financial liberalization was made in the majority of emerging markets in the late 1980s. Such decomposition, important and appealing as it is, can be criticized on at least two grounds. Firstly, there are many countries in the sample that have undertaken the liberalization process during 1990-1992 according to official liberalization dates. Secondly, these studies have ignored the evolutionary and gradual character of financial liberalization seeing that they have not considered a very important phase in the liberalization process, namely the maturity stage in which countries have completed with financial liberalization process and they became able to treat any conditions related to their new financial situation. This methodological imperfection is probably responsible of spurious results.

As far as our study is concerned, we split our sample into three sub-periods, the first one refers to the pre-liberalization period, where all the markets have not yet begun the liberalization process (February 1976 - December 1986), the second is called the transition period (January 1987 - November 1997) and the final period (post-liberalization period) called the period of maturity (December 1997 - October 2008). Then, we estimate the VAR(2) model for each sub-period and we report the results related to the Granger non-causality test to assess volatility interdependencies across markets included in our sample. The results are reported in Table 7. A glance at this table leads to conclude to the overall validity of the VAR(2) model in explaining the interdependencies between the volatility series. The explanatory power of the explanatory variables is indeed very high over the three sub-periods (the adjusted R-squared is greater than 70% for most markets). Moreover, it stands out from Table results that there is a strong volatility transmission between markets whatever the sub-period considered. The most important finding is the strengthening of this transmission over the two sub-periods of transition and maturity. There is clear evidence suggesting strengthening spillovers, especially for four emerging markets (Brazil, Chile, South Korea and Mexico) and also for developed markets. In comparison with the results of Granger non-causality test conducted over the period 1976-2008 (see Table 5), we can see the emergence of new causal linkages between emerging markets over the second and the third sub-periods (sub-periods of transition and maturity) (i.e. Argentinean, Chilean and Mexican markets). This finding holds also for the developed markets and especially for the American market whose volatilities affect those of Brazilian, Chilean and Mexican markets.

These findings appear to be entirely consistent with the expected results. They allow concluding that financial liberalization amplifies the international volatility transmission between emerging markets and their developed counterparts on the one hand and across emerging markets on the other hand. With the increasing integration, these markets have become more dependent on each other, which promoted the transmission of financial turbulences from one market to another. This has led regulators in emerging economies to monitor the phenomenon of the volatility especially after the adoption of the financial liberalization process.

It is worth reminding that the studies having focused on identifying the causes of volatility spillovers (Forbes and Rigobon, 2001, 2002; Pritsker, 2000; Masson, 1999) have generally emphasized two main factors, namely the economic and financial interdependence such as commercial linkages, financial transactions, and irrational investors' behavior such as mimicry, lack of confidence and the increase in the risk aversion.

The growing trade integration between emerging and developed markets on the one hand and across emerging markets on the other hand seems to amplify the transmission of volatility. For this reason, we focus our attention in what follows on the weight of trade integration during the liberalization process. Then, we compute the correlation matrix for the trade liberalization indices on the transition period (January 1987-November 1997) and on the maturity period (December 1997-October 2008). The results that are reported in Table 8 clearly indicate that the correlation coefficients depict an upward trend over the maturity period, which translates an increase in trade linkages between markets. This high level of integration is probably responsible to some extent in part for the international transmission of volatility and can also bring about the appearance of the contagion risk.

4.4. Contagion risk

Previous analyzes of volatility transmission have led to results generally supporting the presence of a unidirectional, and sometimes bidirectional, transmission. The financial liberalization has played a central role in the enhancement of such transmission between some financial markets. However, these analyzes have been conducted in a general framework that did not account for a major feature of the international financial environment and especially of the emerging markets economies, namely the proliferation of financial crises over the last decades. This leads us to reflect on the phenomenon of volatility transmission in times of crisis (contagion).

In the following paragraph, we join previous studies and analyze the concept of contagion. For this purpose, we make use of a very widespread technique in finance, whose relevance has been widely tested when it comes to analyzing regime-switching volatility indexes. Indeed, we run the Bai and Perron (2003a) test which consists in dating the potential structural breaks in the series of conditional volatility. This empirical strategy is based on identifying similarities in structural breaks dates between the different markets in order to test the international transmission of volatility and comparing the occurrence dates of crises with the dates of structural breaks so as to have a clear picture about the risk of contagion between markets.

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

A close inspection 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 account for the effect of geographical proximity on this transmission. Indeed, there are some similarities in the structural breaks dates in the Latin American region. See for instance, 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). Likewise, there are similarities in structural breaks dates in the Asian region, especially 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, notably between Japan, Brazil, South Korea and Thailand (1997: 11).

An analysis of the structural break dates with different financial liberalization dates published by Bekaert and Harvey (2000) (the official date, the introduction of the first American Depositary Receipt (ADR) date, the introduction of the first Country Funds date and the increase in net US capital flow dates) shows some similarities. However, these similarities are different depending on financial liberalization dates used and are not verified only for four markets. For India and Mexico, the similarity appears with the introduction of the first ADR date, while it is identified with the official liberalization date for Brazil and Thailand. These results indicate that financial liberalization relatively participates in the transmission of shocks between emerging markets. It is important to note that these results are relatively corroborated by Nguyen (2008) who showed that structural break dates do not always coincide with official liberalization dates but rather with the alternatives event dates of financial liberalization.

So far, we corroborated the presence of volatility transmission between the emerging markets and also between them and the developed ones. To test for the existence of contagion, we proceed to test the volatility transmission during financial crises. To this end, we report all the structural break dates along with the financial crises dates. Then, we choose the most statistically significant financial crises during the three last decades. The results are depicted in table 9.

A close glance at table 10 clearly shows that several structural breaks dates coincide with financial crises dates. It indicates also 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 hit the Latin American countries between 1982 and 1983, the volatility transmission was identified among three countries in our sample, namely Brazil, Chile and Mexico. During the 1997-1998 Asian crisis, several countries have witnessed a volatility transmission across their markets given the presence of multiple structural breaks dates 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 volatility transmission is also identified during the subprime crisis: USA (2007:08), Brazil (2008:09), Chile (2008:09), India (2008:07) and Japan (2008:09). Again, these results are corroborated by several studies which have shown that the proliferation of financial crises during the last decades in the emerging markets raises the problem of contagion (Bekaert et al., 2005; Forbes and Rigobon, 2000). In sum, through our analysis of structural breaks, the contagion is found to be corroborated for many times during several financial crises which characterized the emerging markets.

5. Recommendations for economic policies

Throughout this paper, we were able to verify the existence of the volatility transmission between emerging markets and between them and the developed ones. It also appears that the implementation of the financial liberalization process is likely to enhance the transmission of volatility. Indeed, a more enhanced level of integration can reinforce the interdependencies between emerging and developed markets. These interdependencies appear to be responsible for the transmission of volatility. We note that several studies have examined the interdependencies in emerging economies and confirmed that they are stronger after financial liberalization (Bensafta et Samedo, 2011; Phylaktis and Ravazzolo, 2002; Carrieri et al., 2002; Calvo et Reinhart, 1996).

The proliferation of financial crises over the last decades throughout the world, and more specifically in emerging economies, raises ipso facto the problem of contagion materialized by the transmission of shocks between financial markets during financial crises. The inspection of many works on financial literature shows that contagion constituted a main interest axis in recent decades. Several studies have focused on studying contagion in emerging markets, and they verified that the financial contagion is effective (Bekaert et al., 2005; Forbes and Rigobon, 2001). The empirical investigations results, based on the determination of structural breaks in the volatility series, this paper put forward show that the transmission of shocks is corroborated on several occasions during various financial crises. This finding does lend support to the presence of contagion between emerging markets and their developed counterparts on the one hand and across emerging markets on the other hand.

The important question emerging countries regulators should answer is how to mitigate the risk of contagion. Many studies have attempted to answer this question such as Masson (1999) and Forbes and Rigobon (2000).

The financial liberalization is considered as a potential cause of financial crises (Dell'Ariccia et al., 2012; Ranciere et al., 2006; Eichengreen and Arteta, 2000). Generally, the implementation of a financial liberalization process requires a robust financial infrastructure and must be furthermore accompanied with preventive measures that could reduce the fragility of the financial system and thereby prevent the occurrence of proliferation of financial crises (Ben Salha et al., 2012). Given the high fragility of the emerging countries financial systems, it is necessary to rationalize their openness to the rest of world in order to contain the risk of contagion. More precisely, policymakers must adopt a gradual financial liberalization process. They must also 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 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 to make coordination between them and to establish common prudential rules.

6. Conclusions

This paper has two central purposes. It aims to examine, during a first step, the volatility of the potential linkages existing between emerging and developed markets by making use of the VAR methodology, and especially the Granger non-causality test, the impulse response functions and the variance decomposition of the forecast errors analysis. The impact of financial liberalization on volatility transmission is also assessed while taking into account the gradual character of financial liberalization. In a second step, the risk of contagion is test using a technique based on the determination of the structural break dates.

The empirical results lead to very interesting precepts. Firstly, it has been shown that volatility transmission is effective across emerging markets countries and between emerging markets and their developed counterparts. It has been demonstrated also that geographical proximity is of great importance in the amplification of transmission. The analysis of the impulse response functions shows that the volatility of perturbations in emerging markets reachs the highest level where the shock comes from emerging markets belonging in the same region. It should be noted that the effect of impulses in the most markets on the volatility of emerging markets is not immediate.

When examining the impact of financial liberalization on the volatility transmission, we find that the results are quite consistent with what is expected. More specifically, these results permits to smartly conclude that financial liberalization amplifies the international transmission of volatility, on the one hand, between emerging and developed markets and, on the other hand, across emerging markets.

Finally, through the analysis of the contagion risk by the technique of structural breaks, we were able, in a first step, to confirm the previous results about transmission. Indeed, the similarity in the dates of structural breaks corroborates the presence of a transmission between markets, especially between those belonging to the same region. In a second step, a comparison between the occurrence date of financial crises and the dates of structural breaks allows us to conclude to the existence of high similarity between these two types of dates. This finding confirms that financial shocks may propagate from one market to another during financial crises periods.

These paper's findings have several economic and financial implications. Firstly, they present a particular importance for regulators in emerging countries since they provide some answers about the effect of financial liberalization, especially regarding risk management and stock markets stability. Secondly, they inform foreign as well as domestic investors about financial markets stability in terms of volatility transmission and contagion risk in order to help them make investment decisions.

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Table 1. Basic statistics of stock markets monthly returns

	Mean	Standard deviation	Skewness	Kurtosis	Jarque-Bera	ADF Statistics	Q(6)	Q(12)	ARCH (6)	ARCH (12)
Argentina	0.936	16.526	-0.038	16.081	1968.041^{++}	-18.610^{++}	14.489	19.876	43.117^{++}	50.943^{++}
Brazil	0.616	15.828	-0.675	6.472	159.679^{++}	-16.999^{++}	3.560	11.756	7.604	32.744^{++}
Chile	1.337	7.223	-0.268	4.261	21.596^{++}	-13.005^{++}	16.865^{+}	23.866	8.278	18.58
India	0.569	8.910	-0.070	3.251	0.958	-14.996^{++}	8.321	10.785	15.294^{+}	19.746
South Korea	0.649	10.667	0.186	5.818	92.929^{++}	-15.656^{++}	6.055	9.444	53.687^{++}	65.521^{++}
Mexico	1.382	11.706	-2.463	18.641	3092.773^{++}	-11.418^{++}	33.778^{++}	38.458^{++}	62.181^{++}	62.150^{++}
Thailand	0.430	11.176	-0.477	5.104	61.411^{++}	-15.365^{++}	13.636	36.357^{++}	36.052^{++}	43.047^{++}
Japan	0.243	6.715	0.080	3.886	9.325^{++}	-15.756^{++}	4.939	19.333	2.501	10.305
USA	0.511	4.574	-1.220	9.007	483.631^{++}	-15.678^{++}	0.923	5.790	12.387	16.792

Notes: The table presents basic statistics of monthly returns. Columns 1 to 5 are reserved to the mean (%), the standard deviation (%), the skewness, the kurtosis and the Jarque and Bera normality test statistics. Q (6) and Q (12) are statistics of the Ljung-Box autocorrelation test applied on returns with lags between 6 and 12. ARCH (6) and ARCH (12) are the statistics of the conditional heteroskedasticity test proposed by Engle (1982), using the residuals of the AR (1) model. ADF is the statistics of the ADF unit root test proposed by Dickey and Fuller (1981). The ADF test is conducted without time trend or constant. $^{+}$ and $^{++}$ denote that the null hypothesis of tests (no-autocorrelation, normality, no-stationarity and homogeneity) are rejected at, respectively, 5% and 1% levels. The study period is from 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	Japan	USA
Panel 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)**	0.000 (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)**	0.060 (0.035)	0.180 (0.036)**
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)**	0.840 (0.092)**	0.766 (0.065)**
$(\alpha+\beta)$	0.990	0.983	0.981	0.957	0.812	0.940	0.930	0.900	0.946
Log-likelihood	134.513	223.808	433.066	449.307	368.517	322.118	389.738	538.306	681.665
Panel II: Basic statistics of conditional volatility									
Mean	0.046	0.023	0.007	0.006	0.013	0.015	0.011	0.003	0.002
Standard deviation	0.055	0.017	0.004	0.003	0.028	0.019	0.012	0.001	0.001
Minimum	0.006	0.005	0.002	0.002	0.004	0.005	0.002	0.001	0.0007
Maximum	0.361	0.124	0.023	0.024	0.412	0.210	0.104	0.007	0.018
Jarque-Bera	1742.1++	1345.7++	141.6++	893.4++	226140.1++	27421.5++	4007.6++	90.1++	43833.6++
ADF test	-4.127++	-3.534++	-4.404++	-3.541++	-11.848++	-5.889++	-8.058+	-4.880++	-4.202++
Q(12)	1686.9++	2874.2++	3856.5++	1727.1++	371.85++	923.53++	1210.2++	1516.4++	361.65++
Panel III: Diagnostic of standardized residuals									
Mean	0.004	-0.011	0.017	0.012	-0.062	-0.032	0.012	-0.017	-0.035
Standard deviation	1.002	1.000	1.011	0.996	0.999	1.002	0.999	0.999	0.999
Minimum	-4.398	-4.250	-4.140	-2.658	-4.099	-5.172	-3.969	-3.589	-4.025
Maximum	5.451	2.969	3.530	3.331	4.332	2.312	4.299	3.066	3.313
Skewness	0.262	-0.366	-0.131	0.086	0.201	-1.423	-0.001	0.032	-0.478
Kurtosis	6.690	4.256	3.722	3.398	4.088	7.951	4.532	3.915	4.372
Jarque-Bera	228.67++	34.816++	9.740++	3.097	22.185++	536.86++	38.636++	13.851++	46.082++
Q(12)	9.703	6.323	24.138+	8.557	8.825	34.398++	35.892++	20.681	7.738
$Q^2(12)$	2.179	12.520	14.685	6.668	9.976	11.453	7.945	6.270	10.185
ARCH(12) test	2.512	11.790	14.196	7.048	9.414	11.168	7.486	7.652	11.242

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 ** indicate that coefficients are, respectively, statistically significant at 5% and 1% levels. + and ++ indicate that the null hypothesis of statistical tests (no-autocorrelation, normality, homogeneity and no-stationary) is rejected, respectively, at 5% and 1% levels.

Table 3. Estimate results of VAR(2) model

Independent variables	Estimated parameters	Dependent variables									
		Argentina	Brazil	Chile	South Korea	India	Mexico	Thailand	Japan	USA	World
Argentina	ϕ_{t-1}	**0.955**	-0.019	0.0001	-0.002	**-0.005**	0.006	**0.002**	**0.002**	0.001	0.001
		(0.051)***	(0.016)	(0.0007)	(0.013)	**(0.003)***	(0.022)	**(0.012)***	**(0.001)****	(0.002)	(0.001)
	ϕ_{t-2}	**-0.097**	**0.039**	0.0002	-0.001	0.001	-0.011	-0.005	**-0.002**	-0.0009	-0.001
		(0.050)*	**(0.016)****	(0.0007)	(0.013)	(0.003)	(0.022)	(0.012)	**(0.001)****	(0.0027)	(0.001)
Brazil	ϕ_{t-1}	**0.389**	**0.870**	0.001	0.026	0.003	-0.028	-0.030	**0.005**	-0.010	-0.005
		(0.159)**	**(0.050)*****	(0.002)	(0.041)	(0.009)	(0.070)	(0.037)	**(0.003)***	(0.008)	(0.005)
	ϕ_{t-2}	-0.155	0.035	-0.001	-0.041	0.011	0.039	0.013	-0.004	0.008	0.007
		(0.157)	(0.049)	(0.002)	(0.041)	(0.009)	(0.069)	(0.037)	(0.003)	(0.008)	(0.005)
Chile	ϕ_{t-1}	3.298	-0.393	**0.904**	**2.019**	0.078	0.926	0.017	0.014	0.014	0.036
		(3.661)	(1.156)	**(0.055)*****	**(0.953)****	(0.218)	(1.605)	(0.867)	(0.080)	(0.195)	(0.123)
	ϕ_{t-2}	-2.673	0.229	0.075	**-1.880**	-0.088	-0.731	-0.032	-0.013	-0.019	-0.039
		(3.605)	(1.139)	(0.055)	**(0.939)****	(0.214)	(1.581)	(0.853)	(0.078)	(0.192)	(0.121)
South Korea	ϕ_{t-1}	**0.260**	0.022	0.0004	**0.590**	-0.003	**-0.099**	0.020	0.0001	0.0008	-0.0009
		(0.087)***	(0.027)	(0.001)	**(0.022)*****	(0.005)	**(0.038)*****	(0.020)	(0.0019)	(0.0046)	(0.0029)
	ϕ_{t-2}	**-0.210**	-0.026	0.001	**-0.097**	0.0004	0.053	**-0.056**	-0.002	-0.001	0.0008
		(0.084)**	(0.026)	(0.001)	**(0.021)*****	(0.005)	(0.036)	**(0.019)*****	(0.001)	(0.004)	(0.0028)
India	ϕ_{t-1}	0.748	-0.278	-0.006	-0.226	**0.908**	-0.359	-0.020	-0.019	-0.033	-0.025
		(0.874)	(0.276)	(0.013)	(0.227)	**(0.052)*****	(0.383)	(0.207)	(0.019)	(0.046)	(0.029)
	ϕ_{t-2}	-0.524	0.155	0.011	-0.0002	0.011	0.358	-0.141	**0.039**	0.043	0.004
		(0.877)	(0.277)	(0.013)	(0.228)	(0.052)	(0.385)	(0.207)	**(0.019)****	(0.046)	(0.029)
Mexico	ϕ_{t-1}	0.091	-0.019	**-0.003**	**-0.065**	-0.0003	**0.894**	**-0.040**	-0.0001	**-0.008**	**-0.005**
		(0.104)	(0.033)	**(0.001)****	**(0.027)****	(0.0062)	**(0.045)*****	**(0.024)***	(0.0022)	**(0.005)***	**(0.003)***
	ϕ_{t-2}	-0.079	0.028	**0.003**	0.013	-0.0004	-0.043	0.009	-0.0004	0.004	0.004
		(0.098)	(0.031)	**(0.001)****	(0.025)	(0.0058)	(0.043)	(0.023)	(0.0021)	(0.005)	(0.003)
Thailand	ϕ_{t-1}	-0.146	**-0.164**	0.002	0.034	0.008	**0.291**	**0.662**	-0.0006	0.003	0.007
		(0.233)	**(0.073)****	(0.003)	(0.060)	(0.013)	**(0.102)*****	**(0.055)*****	(0.0051)	(0.012)	(0.007)
	ϕ_{t-2}	0.227	**0.168**	**-0.007**	**0.292**	-0.003	**-0.232**	**0.240**	0.004	-0.006	-0.005
		(0.227)	**(0.072)****	**(0.003)****	**(0.059)*****	(0.013)	**(0.099)****	**(0.053)*****	(0.004)	(0.012)	(0.007)
Japan	ϕ_{t-1}	0.676	**3.970**	-0.018	0.997	-0.019	-1.505	0.399	**0.873**	-0.001	0.035
		(2.559)	**(0.808)*****	(0.039)	(0.666)	(0.152)	(1.122)	(0.606)	**(0.055)*****	(0.136)	(0.086)
	ϕ_{t-2}	**-4.687**	**-2.978**	0.005	0.049	-0.185	**2.189**	**1.248**	-0.022	0.101	0.077
		(2.618)*	**(0.827)*****	(0.040)	(0.682)	(0.155)	**(1.148)***	**(0.620)****	(0.057)	(0.140)	(0.087)
USA	ϕ_{t-1}	-1.322	-0.131	-0.021	-0.499	-0.013	-0.485	0.064	0.002	**0.820**	0.041
		(1.290)	(0.407)	(0.019)	(0.336)	(0.076)	(0.566)	(0.305)	(0.028)	**(0.069)*****	(0.043)
	ϕ_{t-2}	0.835	0.981	**0.053**	-0.123	-0.096	**2.231**	0.426	-0.020	**0.205**	0.034
		(2.079)	(0.656)	**(0.031)***	(0.541)	(0.123)	**(0.911)****	(0.492)	(0.045)	**(0.111)***	(0.069)

Table 3 (*continued*)

Independent variables	Estimated parameters	Dependent variables									
		Argentina	Brazil	Chile	South Korea	India	Mexico	Thailand	Japan	USA	World
World	ϕ_{t-1}	0.741	0.436	-0.014	0.314	0.152	**8.457**	-0.109	-0.014	0.001	**0.747**
		(2.157)	(0.681)	(0.032)	(0.561)	(0.128)	**(0.946)*****	(0.511)	(0.047)	(0.115)	**(0.072)*****
	ϕ_{t-2}	-1.342	**-1.279**	-0.002	0.287	-0.050	**-9.206**	-0.743	0.033	-0.141	-0.015
		(2.576)	**(0.814)***	(0.039)	(0.671)	(0.153)	**(1.129)*****	(0.610)	(0.056)	(0.137)	(0.086)
Constant		0.011	-0.0008	0.0001	-0.0003	0.0012	-0.004	-0.002	0.0004	-0.00002	0.00007
		(0.005)**	(0.001)	(0.0000)	(0.0015)	(0.0003)***	(0.002)*	(0.001)*	(0.0001)***	(0.0003)	(0.00019)
Adjusted R^2		0.882	0.889	0.996	0.912	0.872	0.834	0.830	0.812	0.589	0.678
Wald test for lags exclusion											
Lag 1 : 3953.591 (0.000) Lag 2 : 324.307 (0.000)											

Notes: β_{t-i} is the estimated coefficient of VAR model at lag (t-i). The standard deviations are given in parenthesis. *, ** and *** indicate that the coefficients are significant, respectively, at the 10%, 5% and 1%.

Table 4. Results of Granger non-causality test

Independent variables	Dependent variables									
	Argentina [(a)]	Brazil [(a)]	Chile[(a)]	South Korea [(b)]	India [(b)]	Mexico [(a)]	Thailand [(b)]	Japan	USA	World
Argentina	-	**4.271****	0.588	1.853	1.775	0.078	**4.595****	**3.397****	0.378	0.189
Brazil	1.682	-	0.118	0.325	**2.521***	0.164	0.096	1.762	0.576	1.186
Chile	**2.187***	0.021	-	1.138	**3.339****	0.896	**4.486****	0.217	0.481	0.621
South Korea	**6.151*****	0.121	0.009	-	1.289	0.096	**14.133*****	0.220	0.272	0.075
India	1.427	0.278	0.189	0.330	-	0.388	0.006	**4.626****	0.876	0.294
Mexico	0.192	0.204	**3.466****	0.072	0.103	-	1.138	0.319	2.093	1.168
Thailand	0.512	1.031	**2.732***	**51.989*****	0.820	**12.705*****	-	0.275	0.413	0.689
Japan	**2.705***	**13.743*****	1.624	**12.540*****	0.257	**3.035****	**12.264*****	-	0.287	**2.714***
USA	0.206	0.528	1.934	0.547	0.727	**15.638*****	0.557	0.314	-	0.650
World	0.620	1.326	2.051	**3.065****	1.282	**74.400*****	0.051	0.456	0.806	-

Notes: Results in this table are the statistics of Fisher that represent empirical statistics for the Granger non-causality test applied to the block of lags for each individual variable in each equation in the system. *, ** And *** indicate that the coefficients are significant, respectively, at the 10%, 5% and 1%. [(a)] and [(b)] represent the regional affiliation of each country. [(a)] for the Latin America region and [(b)] for the Asian region.

Table 5. Impulse Response Functions of stock market volatility series (%)

Independent variables	Periods	Dependent variables									
		Argentina	Brazil	Chile	South Korea	India	Mexico	Thailand	Japan	USA	World
Argentina	1-period	1.844	0.076	0.000	-0.017	0.001	0.012	0.006	-0.030	0.002	0.001
	2-period	1.787	0.014	0.0007	-0..017	-0.007	0.040	0.003	0.002	0.003	0.002
	6-period	0.965	0.162	0.002	-0.001	-0.017	0.006	-0.007	0.011	0.001	0.001
	12-period	0.500	0.172	0.003	-0.004	-0.008	-0.007	-0.015	0.005	-0.002	0.001
	24-period	0.211	0.078	0.003	-0.008	0.005	-0.054	-0.021	0.001	-0.004	-0.0004
Brazil	1-period	0.000	0.577	-0.0008	-0.010	0.003	0.007	-0.0008	0.042	0.003	0.004
	2-period	0.224	0.521	-0.0002	0.010	0.005	0.015	-0.017	0.007	-0.003	-0.0002
	6-period	0.409	0.377	-0.0005	-0.014	0.021	0.016	-0.013	0.006	-0.003	0.002
	12-period	0.356	0.242	-0.0003	-0.016	0.027	-0.011	-0.019	0.006	-0.003	0.001
	24-period	0.134	0.115	-0.0006	-0.005	0.017	0.017	0.0009	0.004	0.001	0.001
Chile	1-period	0.000	0.000	0.028	-0.009	-0.0009	-0.042	-0.025	0.041	0.025	-0.006
	2-period	0.053	0.004	0.025	0.042	-0.0002	-0.092	-0.010	0.004	0.021	-0.002
	6-period	0.038	0.062	0.025	-0.016	-0.011	0.203	0.033	0.008	0.024	0.004
	12-period	0.137	0.100	0.024	-0.019	-0.012	0.264	0.014	-0.001	0.015	0.005
	24-period	0.228	0.075	0.023	-0.030	-0.004	0.090	-0.034	-0.001	0.001	0.0008
South Korea	1-period	0.000	0.000	0.000	0.480	0.008	0.006	0.096	0.051	0.002	0.006
	2-period	0.123	0.016	0.0001	0.290	0.008	0.025	0.074	0.004	0.002	0.004
	6-period	-0.010	-0.007	0.000	0.042	0.002	0.003	0.030	0.024	0.0004	0.002
	12-period	-0.029	-0.0001	-0.0007	0.018	0.001	-0.009	0.017	0.001	-0.0003	0.001
	24-period	-0.024	-0.005	-0.001	0.008	0.000	-0.007	0.008	0.0003	-0.0003	0.0002
India	1-period	0.000	0.000	0.000	0.000	0.109	-0.070	0.023	0.005	0.003	0.002
	2-period	0.072	-0.0097	-0.0006	-0.014	0.099	-0.088	0.018	0.002	0.0001	-0.0003
	6-period	0.000	-0.0004	0.001	-0.014	0.065	-0.036	0.010	0.008	0.008	-0.002
	12-period	-0.091	0.056	0.002	-0.005	0.028	0.153	0.045	0.007	0.016	0.002
	24-period	0.018	0.100	0.003	-0.006	0.004	0.198	0.024	0.002	0.010	0.004
Mexico	1-period	0.000	0.000	0.000	0.000	0.000	0.804	0.069	0.009	0.011	0.015
	2-period	0.062	-0.008	-0.002	-0.048	0.002	0.858	0.013	0.002	0.002	0.007
	6-period	-0.009	0.020	-0.001	-0.043	-0.001	0.349	-0.036	0.003	-0.006	0.001
	12-period	-0.018	-0.003	-0.0009	-0.031	0.002	0.041	-0.047	0.000	-0.008	-0.001
	24-period	-0.053	-0.039	-0.0008	-0.003	0.002	-0.052	-0.012	0.0001	-0.003	-0.001
Thailand	1-period	0.000	0.000	0.000	0.000	0.000	0.000	0.419	0.004	0.015	0.017
	2-period	-0.064	-0.043	0.0003	0.017	0.005	0.258	0.278	0.003	0.014	0.017
	6-period	0.003	0.009	-0.005	0.159	0.001	0.102	0.195	0.004	0.003	0.007
	12-period	-0.012	0.023	-0.008	0.095	0.001	0.006	0.103	0.003	-0.001	0.003
	24-period	-0.042	0.001	-0.011	0.037	0.004	-0.053	0.035	0.001	-0.003	0.0005

Tableau 5 (*continued*)

Independent variables	Periods	Dependent variables									
		Argentina	Brazil	Chile	South Korea	India	Mexico	Thailand	Japan	USA	World
Japan	1-period	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.038	0.020	0.019
	2-period	0.013	0.158	-0.001	0.034	0.001	0.095	0.014	0.033	0.016	0.016
	6-period	-0.332	0.141	-0.002	0.069	-0.012	0.218	0.109	0.017	0.016	0.016
	12-period	-0.262	0.081	-0.005	0.067	-0.006	0.168	0.088	0.005	0.006	0.010
	24-period	-0.072	0.005	-0.007	0.022	0.003	-0.017	0.019	0.001	-0.001	0.001
USA	1-period	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.090	0.030
	2-period	-0.097	0.001	-0.002	-0.035	0.003	0.215	0.002	-0.0002	0.074	0.026
	6-period	-0.124	0.131	0.004	-0.086	-0.013	0.460	0.009	-0.002	0.063	0.019
	12-period	0.105	0.226	0.011	-0.099	-0.015	0.530	-0.020	0.004	0.043	0.013
	24-period	0.381	0.221	0.020	-0.100	-0.0006	0.265	-0.083	-0.002	0.013	0.004
World	1-period	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.043
	2-period	0.032	0.018	-0.0006	0.013	0.006	0.365	-0.004	-0.0006	0.000	0.032
	6-period	-0.070	-0.071	-0.001	-0.001	0.009	-0.146	-0.084	0.001	-0.014	0.006
	12-period	-0.198	-0.129	-0.001	-0.002	0.007	-0.241	-0.048	0.0009	-0.010	-0.002
	24-period	-0.212	-0.108	-0.002	0.020	-0.003	-0.057	0.020	-0.0004	-0.0001	-0.0008

Tableau 6. Variance decompositions of stock market volatility series (%)

Dependent variables	Periods	Standard deviation	Independent variables									
			Argentina	Brazil	Chile	South Korea	India	Mexico	Thailand	Japan	USA	World
Argentina	1-period	0.018	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2-period	0.025	98.615	0.756	0.042	0.226	0.078	0.058	0.062	0.002	0.141	0.015
	6-period	0.037	92.699	4.451	0.063	0.170	0.071	0.042	0.036	1.775	0.621	0.068
	12-period	0.042	84.587	8.448	0.361	0.151	0.207	0.041	0.029	4.674	0.627	0.870
	24-period	0.047	73.508	9.697	2.576	0.159	0.351	0.107	0.067	4.822	5.329	3.378
Brazil	1-period	0.005	1.720	98.279	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2-period	0.008	0.945	94.709	0.002	0.041	0.014	0.011	0.301	3.916	0.000	0.055
	6-period	0.012	4.477	84.467	0.580	0.030	0.072	0.065	0.161	7.134	2.266	0.744
	12-period	0.016	9.534	68.158	2.054	0.020	0.343	0.070	0.199	6.733	9.741	3.143
	24-period	0.020	10.193	50.371	3.723	0.017	2.430	0.293	0.177	4.653	21.683	6.454
Chile	1-period	0.0002	0.042	0.099	99.858	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2-period	0.0003	0.064	0.060	98.637	0.000	0.026	0.621	0.007	0.144	0.410	0.026
	6-period	0.0006	0.457	0.041	95.434	0.001	0.057	0.744	1.751	0.317	0.877	0.316
	12-period	0.0009	1.030	0.036	86.397	0.018	0.341	0.456	4.588	1.201	5.692	0.237
	24-period	0.0014	1.234	0.022	68.299	0.093	0.764	0.226	7.989	2.845	18.197	0.325
South Korea	1-period	0.004	0.134	0.045	0.040	99.779	0.000	0.000	0.000	0.000	0.000	0.000
	2-period	0.005	0.187	0.067	0.589	97.464	0.067	0.714	0.093	0.360	0.396	0.057
	6-period	0.007	0.173	0.116	0.499	69.688	0.239	2.283	18.417	3.092	5.448	0.041
	12-period	0.008	0.134	0.306	0.606	51.096	0.276	2.847	26.168	6.887	11.618	0.058
	24-period	0.009	0.196	0.413	1.455	39.345	0.225	2.581	24.769	7.626	23.057	0.327
India	1-period	0.0010	0.013	0.086	0.008	0.658	99.232	0.000	0.000	0.000	0.000	0.000
	2-period	0.0014	0.256	0.165	0.004	0.644	98.480	0.025	0.154	0.016	0.054	0.196
	6-period	0.0022	1.843	2.314	0.586	0.405	92.254	0.023	0.179	0.839	0.821	0.731
	12-period	0.0026	2.845	7.388	1.858	0.319	81.957	0.032	0.137	1.394	2.866	1.201
	24-period	0.0028	2.701	13.938	2.742	0.291	73.689	0.175	0.276	1.323	3.647	1.212
Mexico	1-period	0.008	0.025	0.007	0.269	0.007	0.763	98.926	0.000	0.000	0.000	0.000
	2-period	0.012	0.106	0.016	0.622	0.040	0.772	83.051	4.020	0.543	2.795	8.029
	6-period	0.019	0.091	0.027	2.295	0.028	0.773	65.599	4.703	3.529	17.582	5.369
	12-period	0.025	0.053	0.022	7.479	0.020	1.243	39.467	2.855	5.925	34.859	8.071
	24-period	0.031	0.258	0.031	8.927	0.024	6.388	26.576	2.092	4.583	43.007	8.111
Thailand	1-period	0.004	0.022	0.000	0.326	4.848	0.282	2.504	92.014	0.000	0.000	0.000
	2-period	0.005	0.020	0.109	0.266	5.391	0.317	1.806	92.000	0.076	0.002	0.008
	6-period	0.007	0.043	0.163	0.631	3.869	0.213	1.340	84.202	5.659	0.067	3.809
	12-period	0.008	0.127	0.367	0.995	3.070	1.002	2.577	73.242	12.212	0.138	6.264
	24-period	0.009	0.736	0.460	1.422	2.707	3.060	3.339	64.700	12.852	5.112	5.605

Tableau 6 (*continued*)

Dependent variables	Periods	Standard deviation	Independent variables									
			Argentina	Brazil	Chile	South Korea	India	Mexico	Thailand	Japan	USA	World
Japan	1-period	0.0004	0.750	1.300	1.078	1.836	2.016	0.676	1.443	90.899	0.000	0.000
	2-period	0.0005	0.635	2.509	1.245	1.756	1.432	0.604	1.305	90.494	0.002	0.014
	6-period	0.0007	0.748	4.541	0.938	1.479	4.331	0.476	2.224	84.796	0.405	0.055
	12-period	0.0008	0.688	7.005	0.792	1.352	9.455	0.388	3.131	75.433	1.611	0.139
	24-period	0.0008	0.720	11.025	0.960	1.255	11.630	0.343	3.577	67.188	3.142	0.155
USA	1-period	0.0009	0.071	0.094	6.802	0.071	0.141	1.253	2.379	4.352	84.832	0.000
	2-period	0.0012	0.103	0.137	6.980	0.084	0.084	0.781	2.647	4.345	84.835	0.000
	6-period	0.0019	0.096	0.154	9.051	0.046	0.396	0.521	1.520	4.704	81.882	1.625
	12-period	0.0024	0.077	0.223	9.606	0.030	2.115	1.033	0.999	4.281	78.902	2.729
	24-period	0.0027	0.334	0.224	8.965	0.027	5.064	1.551	1.002	3.646	96.528	2.654
World	1-period	0.0006	0.047	0.441	1.163	0.962	0.111	5.999	8.314	9.673	24.594	48.691
	2-period	0.0007	0.129	0.271	0.826	0.964	0.070	4.682	9.926	10.307	26.405	46.416
	6-period	0.0010	0.211	0.370	0.845	1.032	0.201	3.144	9.753	16.517	33.286	34.635
	12-period	0.0011	0.327	0.486	1.940	0.916	0.254	2.486	8.717	20.722	37.215	26.933
	24-period	0.0012	0.333	0.551	2.476	0.833	1.792	2.567	7.984	20.525	38.739	24.194

Table 7. Results of Granger non-causality test before, during and after financial liberalization

Independent variables	Sub-periods	Dependent variables										$\overline{R}^2$
		Argentina	Brazil	Chile	South Korea	India	Mexico	Thailand	Japan	USA	World	
Argentina	02/76 -12/86	-	0.357	0.249	0.399	0.373	0.111	0.142	8.387***	0.630	0.805	0.839
	01/87 -11/97	-	**4.648****	1.770	1.182	0.554	0.149	0.343	1.076	0.183	0.035	0.873
	12/97 -10/08	-	**4.796*****	0.281	1.940	1.848	0.146	0.763	0.216	1.578	1.166	0.836
Brazil	02/76 -12/86	0.449	-	0.215	1.333	1.920	2.074	2.784*	1.394	0.110	0.014	0.844
	01/87 -11/97	1.674	-	0.330	**10.413*****	0.676	0.002	0.188	1.407	0.943	0.958	0.863
	12/97 -10/08	1.123	-	0.091	1.810	0.075	0.095	0.708	0.229	1.226	0.821	0.898
Chile	02/76 -12/86	0.784	0.228	-	0.233	3.013*	0.133	1.908	2.099	0.438	0.545	0.990
	01/87 -11/97	0.419	1.943	-	1.786	0.074	**9.373*****	0.809	**5.697*****	2.227	**4.713****	0.983
	12/97 -10/08	1.604	**2.448***	-	**14.487*****	0.575	**8.417*****	**7.284*****	**4.286****	**2.681***	**3.050***	0.954
South Korea	02/76 -12/86	4.401**	0.196	0.315	-	2.278	0.199	0.966	0.182	0.155	0.642	0.973
	01/87 -11/97	0.504	0.732	0.261	-	0.835	0.338	0.507	0.870	**2.604***	**2.444***	0.471
	12/97 -10/08	0.375	0.809	**3.465****	-	0.064	1.338	1.699	1.181	0.297	1.046	0.804
India	02/76 -12/86	3.800**	0.131	0.039	0.259	-	0.061	0.983	1.295	0.536	0.407	0.919
	01/87 -11/97	0.998	0.362	0.334	0.216	-	0.381	0.150	1.123	0.634	0.267	0.833
	12/97 -10/08	1.395	1.446	1.707	0.478	-	1.818	0.101	0.041	**2.498***	**2.449***	0.673
Mexico	02/76 -12/86	0.633	2.600*	7.109***	0.967	1.548	-	1.877	0.088	0.613	1.396	0.662
	01/87 -11/97	0.054	0.176	0.077	0.151	0.098	-	0.791	0.220	0.647	0.177	0.776
	12/97 -10/08	0.581	**3.330****	0.193	**7.414*****	0.220	-	**4.293****	0.269	0.617	0.595	0.751
Thailand	02/76 -12/86	3.991**	0.526	0.427	0.490	1.782	0.309	-	0.497	0.550	1.462	0.959
	01/87 -11/97	0.192	0.085	1.659	0.107	0.188	**34.387*****	-	0.378	0.113	0.583	0.925
	12/97 -10/08	1.940	**7.919*****	1.171	**11.934*****	0.094	**8.594*****	-	2.106	**2.672***	1.241	0.898
Japan	02/76 -12/86	5.626***	0.969	0.216	0.215	1.286	2.699*	1.107	-	3.974**	2.559*	0.855
	01/87 -11/97	1.076	**8.204*****	0.625	**5.924*****	0.176	0.916	1.480	-	0.715	1.083	0.532
	12/97 -10/08	**4.152****	**4.302****	**7.626*****	**4.376****	**2.943***	**12.578*****	**4.014****	-	0.064	0.344	0.836
USA	02/76 -12/86	0.331	0.664	0.889	0.463	0.460	3.180**	1.339	0.190	-	0.025	0.604
	01/87 -11/97	0.133	0.111	**5.107*****	0.439	0.189	**60.994*****	0.557	0.511	-	2.339	0.669
	12/97 -10/08	0.332	**10.734*****	**3.996****	0.170	1.839	**5.017*****	0.232	0.274	-	0.454	0.667
World	02/76 -12/86	1.170	1.680	0.479	0.261	0.833	3.266**	0.933	0.990	5.523***	-	0.797
	01/87 -11/97	0.026	0.199	1.956	0.973	0.021	**93.995*****	0.262	0.191	1.592	-	0.673
	12/97 -10/08	0.686	**2.699***	**4.533****	0.823	**4.304****	1.677	0.644	0.999	1.538	-	0.736

Notes: Results in this table are the Fisher statistics attached to the Granger non-causality test. *, ** and *** indicate that the coefficients are significant, respectively, at the 10%, 5% and 1%.

Table 8. Correlation matrix of trade openness indices

	ARG	BRE	CHI	COR	IND	MEX	THA	JAP	USA
ARG		**0,652**	**0,764**	**0,431**	**0,749**	**-0,262**	**0,732**	**0,771**	**0,535**
BRE	0,554		**0,587**	**0,255**	**0,479**	**0,002**	**0,680**	**0,424**	**0,316**
CHI	0,367	0,335		**0,659**	**0,849**	**-0,159**	**0,806**	**0,876**	**0,776**
COR	-0,158	-0,060	0,187		**0,725**	**0,031**	**0,556**	**0,667**	**0,714**
IND	0,354	-0,011	-0,184	-0,475		**-0,177**	**0,771**	**0,891**	**0,802**
MEX	0,349	-0,207	0,001	0,017	0,679		**-0,100**	**-0,181**	**0,181**
THA	0,434	0,122	0,132	-0,405	0,726	0,567		**0,760**	**0,723**
JAP	0,336	0,099	0,542	0,283	0,112	0,385	0,276		**0,865**
USA	0,364	-0,105	0,008	-0,254	0,812	0,830	0,785	0,322	

Transition period (01/87-11/97)

Maturity period (12/97-10/08)

Notes: The top part of the table (in bold) represent the correlation matrix of the trade openness indices for the mature period and the symmetric part (at the bottom) shows the correlation matrix for the transition period.

Table 9. 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.

Table 10. Comparative analysis of structural break dates with financial crises dates

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.