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Assessing the Effects of Financial Liberalization and Global Financial Crisis on Stock Market Volatility: Evidence from Smooth-Transition GARCH Models

Emna Bensethom*

Department of Commerce Department, Manouba University Higher Business School of Tunis, Tunisia

Abstract

The aim of this paper is to study the potential effects of liberalization process and global financial crisis on conditional volatility. Our sample comprises three Asian emerging markets (Philippines, Korea and Indonesia) over the period from December 1987 to September 2014.Using the ST-GARCH models, our findings show several interesting facts. First, the ST-GARCH processes perform better than the linear GARCH models, since they take into consideration the regime changes in the conditional volatility. Moreover, these models are able to absorb the nonlinear dependence and the asymmetric effects detected on the residuals. Second, whatever the nonlinear model used (ST-GARCH models), financial liberalization has reduced the conditional volatility. By cons, the global financial crisis has increased the conditional variance of the Asian stock markets. Overall, our results confirm that Asian region cannot fully benefit from financial liberalization, because the negative effects of these crises (notably in terms of financial instability) can minimize the benefits of this process (integration).

Keywords: Financial liberalization • Conditional volatility • Asymmetry and non-linearity tests • ST-GARCH models • Global financial crisis and Asian emerging markets

Introduction

Financial liberalization implemented since the late 1980s seems to have positive effects on emerging economies. Thus, it provides an optimal allocation of capital [1] offers additional risks-sharing opportunities [2] and stimulates long-term economic growth [3]. However, a rapid and uncontrolled financial liberalization process can also lead to fragility of the financial system and asymmetric information problems which consequently amplify the instability of financial markets and induce an increase in costs of capital [4].

The study of the relationship between financial liberalization and stock market volatility seems to be fundamental because, according to modern financial theory, the investment decision depends on the risk-return trade-off and therefore, the construction of an efficient portfolio requires a careful analysis of financial asset volatility. In fact, particular attention has been paid to the financial instability in emerging markets, since these latter are often characterized by higher volatility and higher expected return than developed markets [5].

Indeed, several factors may explain this high volatility. First, the proliferation of economic and financial crises which caused a sharp fluctuation in stock prices is considered the main source of market volatility. Second, the psychological and behavioral biases of investors like *overconfidence,* under and overreactions and herding behaviour also seem to explain a significant part of market volatility [6]. Finally, the free capital mobility across borders resulting from liberalization reforms, can be an important source of stock market instability, financial fragility and occurrence of financial crises [7].

Given the importance of financial liberalization process in explaining the stock market volatility, we will try to study the relationship between the two concepts mentioned above (financial liberalization and market volatility) for three Asian markets (Indonesia, Philippines and Korea) over the period from December 1987 to September 2014 and via ST-GARCH models (while taking into account the global financial crisis).

The rest of this paper is organized as follows. The second section summarizes a related literature survey. The econometric methodology that highlights the link between financial liberalization, global financial crisis and stock market volatility is developed in Section 3. In section 4 we present the empirical results. The main conclusions are developed in section 5.

Literature Review

Despite the considerable benefits of financial liberalization it also seems to have certain costs especially for countries that have recently liberalized their financial system [8] So, the study of the relationship between liberalization process, financial crises and stock market volatility appears necessary because the latter plays a key role in the choice of the portfolio and in the mobilization of capital at national and international level.

In order to better understand the linkage between the concepts mentioned above (liberalization, crises and volatility), we try to treat, on the one hand, the direct link between financial liberalization and volatility and, on the other hand, the relationship between stock market volatility and financial crises.

Financial liberalization and stock market volatility

The evolution of financial liberalization following the gradual elimination of barriers to international capital flows was the main source of the volatility in emerging stock markets. These problems of financial instability have led to a serious economic disruption and severe financial crises [9]. Indeed, the proliferation of financial crises from developing countries in the 1990s and the persistence of the recent global economic crisis required a careful analysis of the relationship between liberalization process, stock market volatility and financial fragility, in order to try to limit, on the one hand, the negative impact of these crises on the global economy [10] and to identify, on the other hand, the preconditions necessary for a *successful* implementation of liberalization process in emerging countries (for emerging economies become more resilient and able to absorb shocks).

***Address for Correspondence:** Emna Bensethom, Researcher, Department, Manouba University Higher Business School of Tunis, Tunisia, Tel: 22749177; E-mail: emnabenset22749177@yahoo.fr*

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Therefore, the impact of financial liberalization on stock market volatility has been examined by several researchers. The results of their studies are mixed. For example showed that the liberalization process has significantly reduced the volatility of emerging capital markets (five stock markets experienced a sharp drop in volatility). By [11] found that the effects of liberalization reforms are to increase rather than reduce the volatility of emerging markets.[12] studied the effects of financial liberalization on the volatility of eighteen emerging markets. He suggested that depending on the specific characteristics of stock markets and the quality of financial institutions, the volatility of emerging markets may increase, decrease or remain unchanged during the post-liberalization period.

Specifically, he showed that markets characterized by a higher degree of transparency, greater investor protection and better quality of institutions (e.g. lower levels of corruption), experienced lower volatility in the post-liberalization period [13] tried to examine the volatility of six emerging markets over the period from January1976 to December 2004. They indicated that financial liberalization process generally reduced the level of stock market volatility and their sensitivity to "News". used the bivariate GARCH-M model and the Bai and Perron stability test to study the effect of the liberalization process on stock market volatility. They showed that structural breaks detected in the volatility of Latin American and Asian emerging markets do not occur simultaneously with the official liberalization dates, but rather coincide with dates of *first ADR*/Country Fund introduction and dates of structural changes in the US capital flow. This confirms that emerging markets primarily react to alternative events of official liberalization. We also mention the study of in which a bivariate BEKK-GARCH model [13,14] is employed. The use of such model allowed measuring the magnitude of changes in emerging stock market volatility that occurred after the implementation of financial liberalization policies. The empirical results proved that liberalization did not in any way lead to an increase in stock market volatility. He also showed that market volatility did not react in the same way to different types of liberalization. Indeed, if volatility is not generally affected by official liberalization, it tends to decrease during an effective liberalization marked by a significant increase in US capital inflows. [15] used the uni and multivariate unobserved components structural time series models and found that the positive effects of financial liberalization reforms on the cyclical characteristics of Asian markets (Philippines, Korea, Taiwan and Thailand) are not yet clear in the medium term, because the amplitude and volatility cycles of these markets have been strengthened following the implementation of financial liberalization process, but recently there has been a downward trend in magnitude and volatility.

Stock market volatility and financial crises

The study of the direct effect of financial liberalization on market volatility does not reflect its true scale, because volatility is influenced by other factors such as financial crises and behavioral biases [16] Indeed, several researchers have tried to study the relationship between financial crises and stock market volatility. For example, [17] indicated that volatility *has generally increased* during the crisis period (Asian and Mexican crises). [18] tried to check whether there are structural changes in the dynamic volatility of four Latin American emerging markets (Argentina, Brazil, Chile and Mexico) and the US stock market, using the SWARCH-L model over 1988-2006 period. He showed, on the one hand, that the short-term interdependencies between Latin American markets strengthened during the Asian, Latin American and Russian crises, but after the period of instability they returned to their initial levels (relatively low) and on the other hand, the existence *of multiple volatility regimes* (structural change in volatility) and a significant increase in volatility during the crisis period. This confirms that the liberalization process caused a moderate change in the volatility of financial markets. [19] used the Markov regime-switching model to study the behavior of the volatility in six Mediterranean stock markets (France, Spain, Greece, Egypt, Tunisia and Turkey) over 1995-2010 period. They found that developed markets are less affected by the Asian and Russian financial crises than emerging markets. [21] found, on the one hand, that financial fluctuations still characterize the dynamics of the Tunisian stock market, even before the opening of the capital account and, on the other hand, that Tunisian investor sentiment is a significant explanation of financial volatility. Ben [22] tried to study the three-dimensional relationship between liberalization process, financial crises and the volatility of 13 emerging stock markets over the period from January 1986 to December 2008. By comparing the effects of liberalization reforms on market volatility at normal times to the ones in periods of crises, they showed firstly, that financial liberalization tends to reduce the probability of occurrence of all types of financial crises (banking, monetary and twin). Secondly, that there is a negative relationship between financial liberalization and volatility (direct effect) and a positive effect of the crises on market volatility (indirect effect). Thirdly, that there is an overall positive impact by combining the two effects (directs and indirect effects), which verifies a general tendency to reduce the volatility after the financial openness. According to these researchers, financial openness has the advantage of reducing probability of occurrence of crises in emerging countries, which increases its ability to reduce market volatility and so, do not neglect the mediating role of crises in the evaluation of the impact of financial liberalization in the volatility of emerging markets. Sakthival et al (2014) examined the effects of the global financial crisis on the volatility of the Indian stock market, using the GJR-GARCH model over the period from 1 March 2005 to 30 December 2012. To this end, they divided the total period into two sub-periods: pre-crisis period (from 01 March 2005 to 30 January 2008) and post-crisis period (from 01 February 2008 to 30 December 2012) and they introduced a dummy variable in the GJR-GARCH model corresponding to this crisis. They found that the stock return volatility increased during the post-crisis period compared to the pre-crisis period (a negative impact of the recent financial crisis on volatility of the Indian stock market). Assaf (2016) tried to test whether the volatility of MENA's stock markets exhibits different behavior before and after the global financial crisis. He showed that there has been a structural change in the dynamics of these markets and that volatility has weakened during the second sub-period (after the 2008 crisis). According to this author, these changes are due to the improvement of certain economic and financial conditions in the MENA region after the crisis and related to the efficiency and the dynamic of its financial markets (e.g., improvement in market microstructure, etc.).

Nonlinear Modeling of Stock Market Volatility

Generally, the functioning of financial markets is far from being perfect because the volatility of these latter is characterized by asymmetric responses to good or bad news. Therefore, the linear GARCH process seems inappropriate to reproduce conditional volatility. So, the alternative solution is the use of nonlinear GARCH models (introducing non-linearity and asymmetry). As a result, several extensions of the nonlinear GARCH model have been developed, such as, for example, the Smooth-Transition GARCH models « ST-GARCH models ».

Overview of ST-GARCH Models

The ST-GARCH models have been developed by Hagerud (1996, 1997) and Gonzalez-Rivera (1998). These authors introduced the concept of a smooth transitioninto the linear GARCH specification, while taking into account the existence of two regimes in which the conditional variance can be described as a combination of different linear GARCH (p, q) processes. The ST-GARCH model can be written as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} [\alpha_i + \alpha_i' F(\varepsilon_{t-d}, c, \gamma)] \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2 \quad (1)$$

Were;

c: is the threshold parameter, ε_{t-d}: is the transition variable, γ: measures the *speed*of *transition* from one *regime* to another, $\alpha_i et \alpha_i'$: are the responses of the volatility to a negative and positive shock of the same magnitude in a LST-GARCH model (α_i must be greater than α_i')and $F(\varepsilon_{t-d}, c, \gamma)$: is the transition function which takes either the logistic form or exponential form.

The exponential function will be defined as follows:

$$F(\varepsilon_{t-d}, c, \gamma) = 1 - \exp\left[-\gamma(\varepsilon_{t-d} - c)^2\right]$$

The exponential function gives rise to the EST-GARCH specification which generates a return process where the dynamics of the conditional volatility depend on the size of the error terms ε_{t-i} (small and large shocks have different effects on σ_t^2). This transition function belongs to the interval [0,1]. Therefore, if $|\varepsilon_{t-d}| \to \infty$, F is equal to one and if ε_{t-d} = c, F is equal to zero.

However, the logistic function takes the following form:

$$F(\varepsilon_{t-d}, \gamma, c) = \left(1 + \exp(-\gamma(\varepsilon_{t-d} - c))\right)^{-1} \quad (3)$$

The logistic function gives rise to the LST-GARCH specification which generates a return process where the dynamics of the conditional volatility depend on the sign of the error terms ε_{t-i}. This transition function is equal to one if ε_{t-d} tends towards+∞ and is equal to zero if ε_{t-d} tends to -∞. By cons, if $\varepsilon_{t-d} = c$, in this case F is equal to $\frac{1}{2}$.

Theparameter$^{\gamma}$ determines the *speed*of *transition between different regimes* ($\gamma > 0$). When the latter tends to +∞, the LST-GARCH model converges to the GJR-GARCH model.

Indeed, the conditional volatility is limited by the following two extreme regimes:

$$* \ if\ \varepsilon_{t-d} \to -\infty, F = 0\ and\ \sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} [\alpha_i] \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$$

$$* \ if\ \varepsilon_{t-d} \to +\infty, F = 1\ and\ \sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} [\alpha_i + \alpha_i'] \varepsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j \sigma_{t-j}^2$$

According to Hagured (1996) and Dufrénot and al., (2004), to check the positivity of the conditional variance and the stationarity of the return process of the EST-GARCH and LST-GARCH models, the following conditions must be respected:

	EST-GARCH	LST-GARCH
Conditions for positivity of the conditonal variance	$\alpha_0 > 0$ $\alpha_i \geq 0$ (i=1.....q) $\alpha_i + \alpha_i' \geq 0$	$\alpha_0 > 0$ $\alpha_i \geq 0$ (i=1.....q) $\alpha_i \geq \lvert\alpha_i'\rvert$
Conditions for stationnarity of the return process	$\sum_{i=1}^{q} [\alpha_i + \max(\alpha_i', 0)] < 1$	$\sum_{i=1}^{q} [\alpha_i - \alpha_i' + \max(\alpha_i', 0)] < 1$

Data Analysis

Sources of the data

The sample includes stock indexes of three Asian emerging markets (Philippines, Korea and Indonesia) over the period from December 1987 to September 2014, in monthly frequency. These indexes are expressed in US dollars to eliminate the exchange rate problems and have been extracted from the MSCI database. All stock indexes are transformed into a percentage of return.

Descriptive statistics for return series

Table 1 summarizes the descriptive statistics of our sample. According to this table, the highest mean return is attributed to the Indonesian stock exchange (0.066%) while Korea's stock market provided the lowest average return (0.045%). As to the risk level, which is computed with the standard deviation, stock market of Indonesia has the highest standard deviation (13,130%) while the lowest risk is attributed to the Philippine stock market (8,808%). Thus, Indonesia has the highest risk/return trade-off, i.e. the highest return goes hand in hand with a higher standard deviation. This is considered to be one of the characteristics of emerging markets. Also, Table 1 shows that the assumption of *normality* is strongly rejected because most of asymmetry coefficients "skewness" are different from zero and negative(the distribution of the series is skewed to the left and the Kurtosis is different from 3). Therefore, the rejection of the null hypothesis of normality and symmetry may be a sign of the nonlinear character of the dynamics of stock market. Indeed, this non-linearity can be explained by financial and economic arguments relating to the market microstructure (e.g. transaction costs and information asymmetry) and behavioral finance (e.g., herding behavior and heterogeneity expectations) (for more details, see Arouri, Jawadi and Nguyen, 2010; Arouri and Jawadi, 2012).

Unit root test of stationarity

To study the stationary of stock index series in log levels, we used the two following unit root tests: the conventional ADF and PP tests and the *Zivot and Andrews* (1992) structural break unit root *tests* (more robust to non-linearity than conventional tests). The results reported in Table 2 show that, with the exception of Indonesia, the two other series in levels (Korea and the Philippines) contain a unit root, but are stationary in first differences. In other words, the series are integrated of order 1 I(1). So, stock markets appear to be weakly efficient with the exception of Indonesia, for which informational efficiency in its weak form cannot be established.

Estimation procedure

According to Dufrénot and al. (2004); Egert and Koubaa (2004), the estimation of STGARCH models requires the following steps:

➢ Step 1: Estimation of the linear AR (p) model under the null hypothesis of homoscedasticity (conditional mean equation) and

Table 1. Descriptive statistics for the return series.

Series	Philippines	Indonesia	Korea
Mean	0.005448	0.006567	0.004495
maximum	0.360116	0.662303	0.534102
Minimum	-0.346525	-0.524732	-0.374780
Standard deviation	0.088077	0.131303	0.102962
Skewness	-0.192598	0.175857	0.186918
Kurtosis	5.040132	8.256814	6.066099
Jarque-Bera	57.65312	371.2606	127.6071
Number of observations	321	321	321

Table 2. Unit root tests of stationarity.

Markets	*ADF (level)*	*ADF (1st difference)*	*PP (level)*	*PP (1st difference)*	*Z &A (level)*	*Z &A (1st difference)*
Philippines	-1.735049	-14.86241	-1.728793	-14.87827	-4.16970	-9.62152
Indonesia	-1.947449	-14.88699	-2.006985	-14.94509	**-5.02951**	-10.1644
Korea	-2.431524	-9.365423	-2.085152	-15.38932	**-6.85964**	-9.57193
Critical Values	**-3.450553 (1%)** **-2.870330 (5%)** **-2.571523 (10%)**	**-3.450617 (1%)** **-2.870359 (5%)** **-2.571538 (10%)**	**-3.450553 (1%)** **-2.870330 (5%)** **-2.571523 (10%)**	**-3.450617 (1%)** **-2.870359 (5%)** **-2.571538 (10%)**	**-5.34000 (1%)** **-4.80000(5%)** **-4.58000(10%)**	**-5.34000 (1%)** **-4.80000(5%)** **-4.58000(10%)**

using the akaike information criteria and the residual autocorrelation tests (ACF, PACF).

- Step 2: Application of heteroskedasticity tests on the residuals issued from the AR (p) model.
- Step 3 : Estimation of the GARCH model (p,q) and the use of the following diagnostic tests on the residuals:

1- Asymmetry tests: sign and size bias tests.

2- Linear and nonlinear ARCH effect tests.

- Step 4: Estimation of the nonlinear ST-GARCH model and application of diagnostic testson the standardised residuals (BDS tests, sign and size bias tests, normality test, Skweness, etc.).

Conditional mean equation: AR (p) model

The application of preliminary tests on residuals (non-linearity and asymmetry tests) requires prior, determination of the conditional mean equation. To this end, we assume that the return series are modeled as a linear autoregressive process. For each market, an AR (p) process is specified for which the optimal lag length obtained is the one that minimizes the Akaike information criterion (AIC) and that eliminates the serial correlation in residuals from mean equation. For Korea, the lag length is zero (p = 0), by cons, for Indonesia and the Philippines, the lag length is one (p = 1). The estimation results of the AR (p) model are presented in Table 3.

The Lagrange Multiplier (LM) test of Engle (1982) reported in table 3 (column 5), shows the presence of an ARCH effect (presence of heteroscedasticity in the return series), because the *p-value* of the test statistics is less than 1%. This allows estimating the GARCH model (p, q). Indeed, after determining the optimal parameter (p) and (q), we obtained a GARCH (1, 1) model, for Korea and Indonesia and a GARCH (1, 2) model, for the Philippines. The estimation results of these models are presented in Table 4.

Table 4 shows, on the one hand, the presence of a nonlinear dependence in the return series, by applying the BDS tests on the standardized residuals from the linear GARCH model (the probability value of test statistics "*p-value*" is less than 1 % and 5% for different values of ϵ/σ, see Table 9). This detection of non-linearity can be explained by the existence of certain frictions in financial markets (e.g. heterogeneous transaction costs, information asymmetry, etc.). And on the other hand, the persistence of the volatility induced by shocks ($\sum\alpha_i+\sum\beta_j$) and which seems to be permanent because the values are close to one (the stationarity hypothesis of the variance is not verified). This confirms that the conditional variance is not constant over time. Under these conditions, the GARCH model seems inappropriate to reproduce the dynamics of stock market volatility, because it could not eliminate the problem of non-linearity (according to BDS test). So, to confirm this finding we applied other diagnostic tests (e.g. asymmetry test and non-linearity test) in the following subsection.

Preliminary tests

To check whether the linear GARCH process is appropriate or other nonlinear specifications should be used, we have applied several diagnostic tests such as sign and size bias tests (asymmetry test) and the nonlinear ARCH effect tests.

Sign and size bias tests

The sign and size bias test proposed by Engle et Ng (1993) consists in testing the null hypothesis of conditional homoscedasticity against the alternative hypothesis of asymmetric

ARCH effect and this, by regressing ε_t^2 (squared residual issued from mean equation) in the variable $\widehat{\omega}_{t-1}$.This test can be carried out by estimating the following regression :

$$\varepsilon_t^2 = \varphi_0 + \varphi_1\widehat{\omega}_{t-1} + \mu_t \quad (4)$$

Table 3. Estimation results of the AR (p) model.

Markets	Philippines	Korea	Indonesia
Models	AR(1)	AR(0)	AR(1)
Intercept	0.0054 (0.919)	0.0048 (0.829)	0.0065 (0.736)
AR(1)	0.1802 (3.267)***	------	0.1785 (3.234)***
ARCH-LM test (P-value)	10.481 (0.0050)***	32.276 (0.0000)***	10.358 (0.0056)***

Table 4. The estimation results of the GARCH (p,q) models.

	Philippines	Korea	Indonesia
GARCH (p,q)	GARCH(1,2)	GARCH(1,1)	GARCH(1,1)
Intercept	0.0007 (1.895)*	0.0012 (1.716)*	0.0013 (2.676)***
α_1	0.020 (0.462)	0.1709 (2.709)***	0.2745 (2.845)***
α_2	0.1516 (1.942)**	--------	---------
β_1	0.7414 (8.679)***	0.7386 (8.331)***	0.6579 (7.178)***
Dummy(LIB)	-0.0010 (-6.988)***	-0.0005 (-1.415)	-0.0017 (-6.738)***
Dummy (crisis)	0.0072 (2.634)***	-0.0003 (-0.585)	0.0828 (2.248)**
$\sum\alpha_i+\sum\beta_j$	0.9130	0.9095	0.9324
$Q_{ss}(5)$	24.529 (0.0002)***	112.553 (0.0000)***	107.504 (0.0000)***
$Q_{ss}(10)$	55.417 (0.0000)***	141.910 (0.0000)***	185.679 (0.0000)***

If $\hat{\omega}_{t-1} = \begin{cases} * S_{t-1}^{-}, \text{in this case, we have the } signbiastest(SB) \\ * S_{t-1}^{-}\hat{\varepsilon}_{t-1}, \text{in this case, we have the } negativesizebiastest(NSB) \\ * S_{t-1}^{+}\hat{\varepsilon}_{t-1}, \text{in this case, we have the } positivesizebiastets(PSB) \end{cases}$

Were;

S_{t-1}^{-}: is a dummy variable that takes the value of 1 if $\hat{\varepsilon}_{t-1} < 0$ and 0 if $\hat{\varepsilon}_{t-1} \geq 0$.

The three tests cited above were applied on return series. The estimation results are shown in Table 5.

The sign bias tests (SB) reported in Table 5 indicate the presence of asymmetry for only part of the stock return chosen for the study. The null hypothesis of no asymmetry is rejected for Korea and Indonesia at the 5% level. As for the negative size bias test, the results are similar (for Korea and Indonesia the null hypothesis of symmetry is rejected at the 1% level). The positive size bias test accepts the presence of asymmetry at the 10% level for the Philippines and at the 1% level for Korea.

B-Linear and nonlinear ARCH effect tests « the LM test »

The Lagrange Multiplier (LM) test of Engle (1982) allows checking the null hypothesis of homoscedasticity (constant variance) against the alternative of STARCH or STGARCH process (as specified in (1)). This test examines the possibility of the existence of a linear or nonlinear ARCH effect in the return series. However, in the case of the STARCH and STGARCH models, the test procedure (LM test) is more complicated since the transition parameter γ is unidentified under the null hypothesis. Following Luukkonen, Saikkonen and Terasvirta (1988) and Hagured (1996), the solution is to replace the transition function $F(\varepsilon_{t-d}, c, \gamma)$ by a lower-orderTaylor series expansionand therefore, the auxiliary regression will be equivalent to:

$$\varepsilon_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \alpha_i' \varepsilon_{t-i}^3 + \mu_t \; (in\ the\ case\ of\ LSTARCH\ model) \quad (5)$$

$$\varepsilon_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \alpha_i' \varepsilon_{t-i}^4 + \mu_t (in\ the\ case\ of\ ESTARCH\ model) \quad (6)$$

Under the null hypothesis of the absence of ARCH effect in the residuals, we have:

$$H_0: \begin{cases} \alpha_1 = \alpha_2 \; \dots\dots \alpha_q = 0 \\ \alpha_1' = \alpha_2' \dots\dots \alpha_q' = 0 \end{cases}$$

Indeed, LM_1 is the appropriate test statistic. The latter has an asymptotic χ^2 distribution with 2 q degrees of freedom and is computed as follows:

$$LM_1 = T \frac{SCR_0 - SCR_3}{SCR_0} (case\ of\ LSTARCH\ model)$$

$$LM_2 = T \frac{SCR_0 - SCR_4}{SCR_0} (case\ of\ ESTARCH\ model)$$

Were;

T: Number of observations.

SCR_0: The residual sum of squared issued from the mean equation ε_t^2.

SCR_3 : The residual sum of squared issued from the equation (5).

SCR_4 : The residual sum of squared issued from the equation (5).

According to the results of the LM test reported in Table 6, we note that the LST-GARCH and EST-GARCH model is accepted against the alternative hypothesis of homoscedasticity (constant variance over time) in the case of Korea and the Philippines at the 1% level and whatever the value of (q) (q = 1.2, 5.10). Also, for the case of Indonesia we obtained the same results, but for high value of (q).

In summarizing, according to the diagnostic tests, the asymmetric and nonlinear ARCH effect appears clearly in the residuals issued from the mean equation, for the case of Korea and Indonesia. So, as already mentioned, this asymmetry and non-linearity is explained by economic factors relating to the market microstructure and behavioral finance. This is considered to be a proof of the superiority of nonlinear models compared to linear ones Table 6.

V.3 Estimation and evaluation of ST-GARCH models

In the previous section we detected the existence of an asymmetric and nonlinear ARCH effect, which allows estimating the ST-GARCH models (EST-GARCH and LST-GARCH).

Table 5. Results of asymmetry tests (P-value).

	Sign bias test (SB test) (P values)	Negative size bias test (NSB test) (P values)	Positive size bias test (PSB test) (P values)
Philippines	0.511 (0.609)	-0.2342 (0.8149)	-1.740 (0.083)
Indonesia	2.059 (0.040)	-3.9391 (0.0001)	0.472 (0.637)
Korea	2.463 (0.014)	-8.155 (0.000)	-3.7159 (0.0002)

Table 6. Results of nonlinear ARCH tests.

		q=1	q=2	q=5	q=10
Philippines	Sta LM_1 (p values)	313.299 (0.000)	313.801 (0.000)	314.160 (0.000)	314.621 (0.000)
	Sta LM_2 (p values)	313.320 (0.000)	313.553 (0.000)	314.164 (0.000)	315.046 (0.000)
Indonesia	Sta LM_1 (p values)	11.820 (0.019)	14.015 (0.008)	38.608 (0.000)	79.559 (0.000)
	Sta LM_2 (p values)	26.757 (0.000)	27.285 (0.000)	34.460 (0.000)	75.018 (0.000)
Korea	Sta LM_1 (p values)	310.581 (0.000)	312.770 (0.000)	314.578 (0.000)	314.963 (0.000)
	Sta LM_2 (p values)	307.632 (0.000)	309.154 (0.000)	310.010 (0.000)	310.771 (0.000)

To analyze the impact of financial liberalization and the global economic crisis on stock market volatility, we have introduced into the ST-GARCH model two dummies variables corresponding to liberalization reforms and crisis.

Indeed, after determining the optimal value of parameters (p) and (q), we will estimate a STGARCH (1,1) model for Indonesia and Korea and a ST-GARCH (1,2) model, for the Philippines, by using the near-maximum likelihood method. These models take the following forms:

$$\mathbf{STGARCH(1,1)}: \sigma_t^2 = \alpha_0 + [\alpha_1 + \alpha_1' F(\varepsilon_{t-1}, c, \gamma)]\varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + D_{LIB} + D_{CRISIS} \quad (7)$$

$$\mathbf{STGARCH(2,1)}: \sigma_t^2 = \alpha_0 + [\alpha_1 + \alpha_1' F(\varepsilon_{t-1}, c, \gamma)]\varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \beta_2 \sigma_{t-2}^2 + D_{LIB} + D_{CRISIS} \quad (8)$$

Were;

D_{LIB}: is a dummy variable corresponding to the capital market liberalization. It takes the value of zero before the official liberalization dates and the value of one after the official liberalization dates (Official capital marketliberalization dates are presented in the Table 7).

D_{CRISIS}: is a dummy variable corresponding to the global economic crisis. It takes the value of zero before the crisis period (from December 1987 to September 2008) and value one after the crisis period (from October 2008 to September 2004).

The estimation results of the ST-GARCH model presented in Table 8 suggest that the value of the parameter $\alpha_1{}'$ is lower than the value of α_1, in the case of the Philippines. This indicates that for the estimated LST-GARCH model, negative shocks increase conditional volatility more than positive shocks of the same size (the condition of positivity of the conditional variance for the LSTGARCH model is verified, in the case of the Philippines).

For the estimated EST-GARCH model, the results reported in Table 8 show that small and large shocks have different effects on conditional volatility, thus highlighting the size effect of residuals for the three Asian markets. Also, the transition parameter γ is lower for the EST-GARCH model than the LST-GARCH model, in the case of Korea. So, the transition between different regimes is smooth for the EST-GARCH model and more abrupt for the LST-GARCH model. By cons, in the case of Indonesia and the Philippines, the transition is rather abrupt for the EST-GARCH model and smooth for the LST-GARCH model.

The results of the BDS tests (Table 9) applied on the standardized residuals issued from the GARCH, EST-GARCH and LST-GARCH models show the superiority of the non-linear models (LST-GARCH and EST-GARCH models) compared to the linear GARCH process, since the p-values for the GARCH model are higher than the LST-GARCH and EST-GARCH models (the nonlinear serial dependence has become weak for the ST-GARCH models). In addition, by comparing the p-values of the LST-GARCH and EST-GARCH models, we find that the second (EST-GARCH) are able to absorb the nonlinear serial dependence better than the first (LST-GARCH), since the probability values are lower for EST-GARCH models than the LST-GARCH models. This confirms the results obtained by Dufrénot and al. (2004); Egert and Koubaa (2004) and Khemeri (2011). These authors have

Table 7. Official capital markets liberalization dates (Asian emerging markets).

Region	Markets	Official equity market liberalization dates	Period of study	Number of observations
Asia	Indonesia	September 1989	From 12/1987 to 09/2014	322
	Philippines	June 1991	From 12/1987 to 09/2014	322
	Korea	January 1992	From 12/1987 to 09/2014	322

Table 8. The estimation results of the LSTGARCH and ESTGARCH models.

Markets	Philippines		Korea		Indonesia	
Models	LSTGARCH(2,1)	ESTGARCH(2,1)	LSTGARCH(1,1)	ESTGARCH(1,1)	LSTGARCH(1,1)	ESTGARCH(1,1)
α_0	0.0112 **(137.194)*****	0.0087 **(6.009)*****	0.0004 **(102.050)*****	-0.0001 **(-86.805)*****	0.0447 **(16.093)*****	0.0392 **(44.913)*****
α_1	0.2268 **(2.472)****	0.1022 **(27.794)*****	-0.1710 **(-140.334) *****	-0.1941 **(-46.759)*****	0.1629 **(11.247)*****	0.2290 **(7.506)*****
α_2	0.0244 **(97.413)*****	0.1638 **(3.743)*****	--------	--------	--------	--------
β_1	0.5066 **(38.553)*****	0.0710 **(43.086)*****	0.1006 **(46.236)*****	0.1005 **(721.600)*****	0.3434 **(17.089)*****	0.0071 **(59.328)*****
$\alpha_1{}'$	0.1527 **(1.650)***	0.0001 **(13.349)*****	0.7598 **(58.101)*****	0.1315 **(26.575)*****	0.2112 **(24.059)*****	0.0142 **(11.555)*****
$\alpha_2{}'$	0.1682 **(180.431)*****	0.00001 **(9.748)*****	--------	--------	--------	--------
δ	8.9132 **(3.486)*****	11.7951 **(51.970)*****	6.6619 **(83.842)*****	0.8450 **(58.675)*****	2.5724 **(10.040)*****	41.2201 **(8.879)*****
c	0.0163 **(12.741)*****	0.0035 **(94.224)*****	-0.3187 **(-134.430)*****	0.3288 **(77.440)*****	-0.1542 **(-32.100)*****	0.00026 **(5.514)*****
Dummy(lib)	-0.0023 **(-26.549)*****	-0.0037 **(-2.347)****	-0.0001 **(-2.960)*****	-0.0001 **(-96.644)*****	-0.0417 **(-15.254)*****	-0.0296 **(-26.476)*****
Dummy(crise)	0.0232 **(88.419)*****	0.0108 **(1.717)***	0.0003 **(10.335)*****	0.0003 **(25.809)*****	0.0054 **(1.890)***	0.0027 **(81.380)*****
AIC	-1.966	-2.057	-2.067	-2.066	-1.486	-1.121
ARCH(4) (p-value)	1.452 **(0.229)**	0.470 **(0.493)**	0.107 **(0.980)**	0.089 **(0.985)**	0.164 **(0.848)**	0.104 **(0.981)**
LjungBox(12)	30.18 **(0.697)**	29.81 **(0.717)**	8.91 **(0.710)**	9.17 **(0.688)**	37.90 **(0.338)**	28.13 **(0.788)**
SE	0.0873	0.0834	0.1033	0.1033	0.1245	0.1243

Table 9. Results of the BDS test.

		GARCH		ESTGARCH		LSTGARCH	
	Dimensions (m)	z-statistic	(P –value)	z-statistic	(P –value)	z-statistic	(P –value)
ϵ/σ=0.25							
Philippines	2	-3.00455	**0.00266**	-1.02349	**0.30608**	-0.57823	**0.56311**
	3	-3.45192	**5.56603e-04**	-1.00430	**0.34504**	-2.18004	**0.02925**
	4	-4.08610	**4.38693e-05**	1.08197	**0.27927**	-1.76356	**0.07781**
Indonesia	2	1.50446	**0.13246**	-2.17617	**0.02954**	3.49471	**4.74575e-004**
	3	3.03251	**0.00243**	0.22089	**0.82518**	4.37933	**1.19043e-005**
	4	3.86877	**1.09386e-004**	0.15264	**0.93135**	4.11022	**3.95291e-005**
Korea	2	1.80529	**0.07103**	0.59797	**0.54986**	-1.40029	**0.16143**
	3	1.89796	**0.05770**	0.10448	**0.91678**	0.15943	**0.87333**
	4	1.10466	**0.26930**	3.20903	**0.00133**	0.35707	**0.72104**
ϵ/σ=0.5							
Philippines	2	-1.94751	**0.05147**	-0.42699	**0.66939**	-0.54088	**0.58859**
	3	-1.74590	**0.08083**	-1.28097	**0.20020**	-0.75787	**0.44853**
	4	-1.91205	**0.05587**	-1.29230	**0.19625**	-0.38856	**0.69760**
Indonesia	2	2.24327	**0.02488**	-0.64771	**0.51718**	3.78819	**1.51747e-004**
	3	2.84663	**0.00442**	-0.12888	**0.89745**	4.27278	**1.93053e-005**
	4	3.35002	**8.08044e-004**	-0.09909	**0.92107**	4.58313	**4.58056e-006**
Korea	2	3.05948	**0.00222**	0.28049	**0.77910**	-0.00549	**0.99562**
	3	4.29888	**1.71661e-005**	0.63779	**0.52361**	0.13700	**0.89103**
	4	5.48520	**4.12995e-008**	0.94447	**0.34493**	0.46942	**0.63877**
ϵ/σ =1							
Philippines	2	-1.50324	**0.13278**	0.00680	**0.99458**	0.08380	**0.93322**
	3	-1.41575	**0.15685**	-0.05058	**0.95966**	0.45526	**0.64892**
	4	-1.47408	**0.14046**	0.28163	**0.77823**	0.67871	**0.49732**
Indonesia	2	3.94798	**7.88147e-005**	-0.26337	**0.79227**	5.06041	**4.18355e-007**
	3	4.84088	**1.29262e-006**	0.13944	**0.88910**	5.88292	**4.03089e-009**
	4	5.63105	**1.79116e-008**	0.50411	**0.61418**	6.58496	**4.54996e-011**
Korea	2	4.37651	**1.20597e-005**	0.67565	**0.49926**	0.20185	**0.84003**
	3	5.65287	**1.57794e-008**	0.73866	**0.46012**	0.56581	**0.57153**
	4	6.67682	**2.44190e-011**	0.52760	**0.59777**	0.29223	**0.77011**
ϵ/σ =1.5							
Philippines	2	-1.65331	**0.09827**	0.32524	**0.74500**	0.39270	**0.69454**
	3	-1.52012	**0.12848**	0.19152	**0.84812**	1.03968	**0.29849**
	4	-1.99533	**0.04786**	0.51513	**0.60646**	1.39909	**0.16179**
Indonesia	2	5.17206	**2.31522e-007**	-0.34996	**0.72637**	5.61959	**1.91415e-008**
	3	6.08049	**1.19818e-009**	0.24998	**0.80260**	6.52111	**6.97907e-011**
	4	6.64880	**2.95488e-011**	0.50908	**0.61070**	6.99954	**2.56805e-012**
Korea	2	5.68025	**1.34501e-008**	1.38112	**0.16724**	0.79168	**0.42855**
	3	7.17098	**7.44621e-013**	1.42113	**0.15528**	1.08108	**0.27966**
	4	7.96970	**1.59055e-015**	1.25845	**0.20823**	0.82506	**0.40934**
ϵ/σ=2							
Philippines	2	-1.81096	**0.07015**	0.36429	**0.71564**	0.57547	**0.56497**
	3	-1.59707	**0.11025**	0.34185	**0.73247**	1.28126	**0.20010**
	4	-1.63456	**0.10214**	0.60024	**0.54835**	1.52438	**0.12741**
Indonesia	2	4.66422	**3.09797e-006**	-0.63275	**0.52690**	4.66477	**3.08964e-006**
	3	5.72114	**1.05809e-008**	-0.23458	**0.81454**	5.59865	**2.16029e-008**
	4	6.34232	**2.26333e-010**	-0.12196	**0.90293**	5.94528	**2.75983e-009**
Korea	2	6.48214	**9.04287e-011**	2.01283	**0.04413**	1.86367	**0.06237**
	3	7.91170	**2.53888e-015**	2.04415	**0.04094**	2.12716	**0.03341**
	4	8.48906	**2.08323e-017**	1.73031	**0.08358**	1.78898	**0.07362**

shown the superiority of the ST-GARCH models compared to the linear GARCH models.

According to the results of the asymmetry test reported in Table 10, we see, in the case of the Philippines and Korea that the LST-GARCH model could absorb the asymmetric effect already detected since the p-values have become more than 10%.

In summary, Table 11 provides a comparative study between linear GARCH models and non-linear ST-GARCH processes. Indeed, for the Philippines, the EST-GARCH and LST- GARCH models can be selected to reproduce the dynamics of conditional volatility. However, in estimating these two models, the Akaike information criteria (Table 8) allow us to conclude that the EST-GARCH specification is better than the LST-GARCH model. Therefore, the EST-GARCH model is retained for all stock indices selected for the study (Korea, Indonesia and the Philippines). This highlights the size effect of shocks (magnitude), so that small and large shocks have different effects on stock market volatility (large shocks increase volatility more than small shocks of the same sign).

So, Table 11 confirms that ST-GARCH processes perform better than the linear GARCH models, since they can reproduce the market volatility in the presence of certain phenomena detected in the financial markets in particular, volatility clustering and leverage effect.

Now, we will focus on the effect of financial liberalization and the global

Table 10. Result of the asymmetry test (LST-GARCH model).

	(SB test) (P values)	(NSB test) (P values)	(PSB test) (P values)	General effect (SB, NSB and PSB) (P values)
Philippines	0.549 (0.583)	-1.482 (0.139)	-0.429 (0.668)	2 .479 (0.486)
Indonesia	1.406 (0.161)	-2.265 (0.024)	-0.383 (0.701)	5.253 (0.163)
Korea	1.189 (0.235)	-0.297 (0.766)	-1.738 (0.083)	3.323 (0.490)

Table 11. Comparative study between GARCH and ST-GARCH models.

		GARCH	EST-GARCH	LST-GARCH	Conclusions
Philippines	Conditions for positivity of the condtional variance	---------	Verified	Verified	-The conditions for positivity of the conditional variance are verified for ESTGARCH and LSTGARCH models -The p-values for the different diagnostic tests are higher for the ESTGARCH and LSTGARCH models compared to the linear GARCH model. Thus, we can conclude that the standardized residuals issued from the STGARCH model (logistic and exponential) have the best properties than those issued from the GARCH model.
	Asymmetry test (general effect)	4.886 (0.185)	----------	2 .479 (0.486)	
	Skewness	0.177 (0.198)	-0.244 (0.076)	-0.162 (0.238)	
	Kurtosis	5.358 (0.000)	1.522 (0.000)	2.112 (0.000)	
	Jarque-Bera	385.721 (0.000)	34.093 (0.000)	60.876 (0.000)	
	BDS test (P-value) c/σ=0.5	0.05147 (m=2)	0.66939 (m=2)	0.58859 (m=2)	
		0.08083 (m=3)	0.20020 (m=3)	0.44853 (m=3)	
		0.05587 (m=4)	0.19625 (m=4)	0.69760 (m=4)	
	ARCH(4) (p-value)	0.005	0.493	0.229	
Korea	Conditions for positivity of the conditional variance	----------	verified	not verified	-The conditions for positivity of the conditional variance are not verified for LSTGARCH model. -The p-values for the different diagnostic tests are higher for the ESTGARCH model compared to the linear GARCH model. Thus, we can conclude that the standardized residuals issued from the ESTGARCH model have the best properties than those issued from the GARCH model. This indicates that stock market volatility depends on the size of shocks (small and large shocks do not even affect volatility).
	Asymmetry test (general effect)	64.833 (0.000)	----------	3.323 (0.490)	
	Skewness	0.187 (0.172)	-0.295 (0.031)	-0.270 (0.049)	
	Kurtosis	3.055 (0.000)	-0.341 (0.216)	-0.262 (0.342)	
	Jarque-Bera	127.088 (0.000)	6.247 (0.044)	4.848 (0.088)	
	BDS test (P-value) c/σ=0.5	0.00222 (m=2)	0.77910 (m=2)	0.99562 (m=2)	
		1.71661e-005 (m=3)	0.52361 (m=3)	0.89103 (m=3)	
		4.12995e-008 (m=4)	0.34493 (m=4)	0.63877 (m=4)	
	ARCH(4) (p-value)	0.000	0.985	0.980	
Indonesia	Conditions for positivity of the conditional variance	----------	verified	not verified	-The conditions for positivity of the conditional variance are verified for ESTGARCH model. -The p-values for the different diagnostic tests are higher for the ESTGARCH model compared to the linear GARCH model. Thus, we can conclude that the standardized residuals issued from the ESTGARCH model have the best properties than those issued from the GARCH model. This indicates that stock market volatility depends on the size of shocks (small and large shocks do not even affect volatility).
	Asymmetry test (general effect)	23.325 (0.000)	----------	5.253 (0.163)	
	Skewness	-0.193 (0.159)	0.301 (0.029)	0.417 (0.002)	
	Kurtosis	2.091 (0.000)	3.658 (0.000)	3.733 (0.000)	
	Jarque-Bera	60.493 (0.000)	183.266 (0.000)	195.061 (0.000)	
	BDS test (P-value) c/σ=0.5	0.02488 (m=2)	0.51718 (m=2)	1.51747e-004 (m=2)	
		0.00442 (m=3)	0.89745 (m=3)	1.93053e-005 (m=3)	
		8.08044e-004 (m=4)	0.92107 (m=4)	4.58056e-006 (m=4)	
	ARCH(4) (p-value)	0.001	0.980	0.493	

financial crisis on conditional volatility, which is the main objective of this paper. Indeed, whatever the nonlinear model used (LST-GARCH or EST-GARCH models) the variable liberalization is statistically and negatively significant. This indicates that financial liberalization has reduced the conditional volatility of the Asian emerging markets, which confirms the results obtained by Bekeart and Harvey (1997); Nguyen and Bellalah (2008); Umutlu, Akdeniz and Altay-Salih (2010) and Mnif trabelsi (2014). These authors have proved the existence of a negative effect of liberalization on emerging stock market volatility (financial liberalization reduces market volatility). By cons, the variable crisis is statistically and positively significant, implying that the global crisis has increased the conditional variance of the Asian stock markets. This confirms the results obtained by Sakthival et al (2014) and Assaf (2016). These researchers showed the existence of a positive relationship between the global crisis and stock market volatility (financial market volatility increased during the crisis period).

So, we can conclude that financial openness is always beneficial for emerging economies, as it allows them to reduce the stock market volatility in the long run, but this is only true when these economies take into account some initial conditions, before the implementation of liberalization policy. Indeed, Nguyen (2010) suggested that "strengthening the prerequisites for a well-functioning financial market is essential to avoid any sources of financial instability. These conditions include the financial infrastructure, the quality and quantity of information disseminated and the education of investors in terms of the nature of financial securities and portfolio management. It should also give priority to measures aimed at making the markets more transparent such as the adoption of international accounting standards". For their part, Ben Rejeb and Boughrara (2013) have indicated, on the one hand, that it is necessary to take into consideration the mediating role of financial crises when assessing the effects of liberalization reforms on economic and financial aspects and, on the other hand, the importance of the prerequisites for the success of the liberalization process. In other words, strengthening the preconditions for a well-functioning financial market and the need for a gradual deregulation are the two main factors in ensuring the success of liberalization.

It should be noted that our study can inform investors about the volatility and the performance of stock markets, which help them tomake an investment decision that depends, according to modern financial theory, not only on the level of expected return but also on the level of portfolio risk (Nguyen, 2010).

Conclusion

In this paper, we have tried to examine the effects of official liberalization dates and the global economic crisis (2008, 2009) on conditional volatility of three Asian emerging markets. Using the Smooth Transition GARCH models, our findings show several interesting facts. First, the ST-GARCH processes perform better than the linear GARCH models, since they take into consideration the regime changes on the conditional volatility. Moreover, these models (STGARCH models) are able to absorb the nonlinear dependence and the asymmetric effect detected on the residuals (according to the BDS test and the asymmetry test). Second, whatever the nonlinear model used (EST-GARCH or LST-GARCH models), financial liberalization has reduced the conditional volatility. By cons, the global financial crisis has increased the conditional variance of the Asian stock markets, thus confirming the results obtained by Sakthival et al (2014) and Assaf (2016). These researchers have proved the existence of a positive relationship between the global financial crisis and stock market volatility (the crisis increases the conditonal volatility). There by, we can conclude that Asian markets, which are often characterized by higher global integration than regional one (Guesmi and Nguyen, 2011; Ananchotikul, Piaoand Zoli, 2015), cannot fully benefit from financial integration, because the negative effects of these crises (notably in terms of financial instability) can minimize the benefits of this process (integration). Thus, Asian policymakers by reducing the *probability of occurrence of crises* can minimize the stock market volatility, in the long run. In other words, they must give considerable importance to the mediating role of financial crises, when assessing the effects of liberalization reforms on emerging stock markets (Ben rejeb and Boughrara, 2013).

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