CREDIT RATING ANNOUNCEMENTS AND STOCK MARKET VOLATILITY DURING CRISES: Evidence from the MENA Region

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ABSTRACT

The aim of this study is to assess the impact of rating change announcements on Middle East and North Africa (MENA) stock market volatility over the period December 2010 to August 2022. The study period covers two major crises: the political crisis associated with the outbreak of the Arab Spring and the COVID-19 health crisis. It focuses on 12 countries divided into emerging countries and frontier countries. Using the exponential generalized autoregressive conditional heteroscedasticity model (EGARCH) and a panel regression, we better specify the impact of different rating change announcements on the volatility of stock market returns.

The results showed, first, that volatility persisted over the study period in most countries. Second, the study found an asymmetry in the reaction of stock market volatility to different rating announcements. In times of crisis, these markets react strongly to downgrading announcements and do not react to neutral or upgrade announcements. Third, rating changes showed a lack of interdependence among stock markets in the MENA region.

Keywords: Volatility; Financial ratings; stock market returns; EGARCH models; asymmetric stock market reactions; interdependence.

JEL classification: E44, G24

1. Introduction

Since the 1990s, the role of credit rating agencies (CRA) has grown as a benchmark and they have become part of banking and legal teams. Credit rating agencies alleviate the problems of information asymmetry between market participants (issuers, investors and regulators). Produced and disseminated information on credit risk is used by investors in the decision-making process (Norden & Weber, 2004; Von Schweinitz & El-Shagi, 2016; and Degos et al., 2012).

The relationship between the announcement of a rating and the variation in stock prices has been confirmed by global financial crises, in particular the financial and economic crisis of 2008-2009. Moreover, the major financial crises, such as the Asian crisis in 1997 and the subprime crisis in 2007, clearly show the huge impact of rating agencies on the decisions of issuers and investors. Indeed, the market reacts strongly to any actual rating change, and sometimes irrationally, to a mere announcement of a hypothetical rating revision.

After the financial and economic crisis of 2008-2009, the volatility of financial markets around the world increased significantly. Indeed, such volatility can cause a high level of financial instability and increase the level of risk and uncertainty among market participants (Hamouda et al., 2022).

Our study is motivated, on the one hand, by the excessively negative trend in country and company ratings listed in the Middle East and North Africa (MENA) region in recent years. On the other hand, global stock markets are heavily impacted by rating changes, which leads us to question how MENA markets react to rating changes.

The purpose of this paper is to study the volatility of stock market returns in Middle East and North Africa (MENA) countries during and after the recent crises, including the severe health crisis of the COVID-19 epidemic and the political, social and economic crises associated with the outbreak of the Arab revolutions. Similarly, the MENA region has experienced in recent years an excessive negative evolution of country ratings as well as ratings of listed companies according to the publications of rating agencies. Our study period extends from the end of 2010 to the year 2022; this period includes the two previously mentioned crises.

Our contributions focus on the following aspects: (i) we analyse rating announcement influences on the volatility of stock returns (significance); (ii) we examine the differences between the effects of positive and negative ads (the skewness); and (iii) we assess whether a rating change in one country influences the volatility of stock markets in neighbouring countries in the same zone (interdependence between markets).

This paper is organized in six sections. Following this introduction, section 2 will review the literature on the impact of rating changes on stock market volatility. Section 3 presents the main data used and the empirical methodology. The results of measuring the volatility of stock market returns are reported in section 4. Section 5 presents the main results of the evaluation of the reaction of stock market volatilities to changes in ratings and the study of the interdependence between stock markets. Finally, the general conclusion drawn is provided in section 6.

2. Impact of Rating Changes on Stock Market Volatility: A literature review

The extended role of rating agencies in financial markets is based on three financial theories. First, the agency theory (Jensen & Meckling, 1976) which states that any contractual relationship is an agency relationship involving the risk of asymmetric information[1]. Secondly, the information theory (Spence, 1973) which suggests that ratings are a signal from managers to investors concerning their transparency and credibility. Thirdly, the efficient market hypothesis (Fama, 1965) which assumes that ratings should only impact asset prices if they contain additional information not known to the public.

The relationship between financial ratings and the stock market is widely discussed in the literature. Afonso et al. (2014) showed that changes in sovereign ratings have asymmetric effects on stock and bond volatility. Indeed, upgrades do not have a significant effect on volatility, but downgrades increase the volatility of stock and bond markets. Also, they showed contagion and interdependence between the European financial markets.

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[1] According to Jensen and Meckling (1976), a situation of asymmetric information arises in a contractual relationship when two people do not have the same level of information. On the capital markets, due to the lack of necessary information, investors refer to the ratings issued by the rating agencies to assess the credit risk of issuing companies. In this case, the rating agencies act as ‘agents’ for all investors, who are referred to as ‘principals’. They are highly informative. They have the advantage of receiving insider information from issuers.

Ouattara (2017) showed that stock prices listed on the West African Regional Securities Exchange react to the dissemination of financial ratings. Similarly, Mutize and Nkhalamba (2020) studied the impact of credit rating changes on South African sovereign bond yields over the period 2007-2018. The results showed that investors are more sensitive to negative credit rating events.

Similarly, Baulant and Albouz (2021) showed that changes in ratings not anticipated by the market affect the performance of the Brazilian stock market and the volatility of stocks and that this volatility is highly asymmetric; bad news about returns has a greater impact on volatility than good news.

Chodnicka-Jaworska (2020), for the period 2000-2021, showed a direct and significant impact of the COVID-19 pandemic on changes in credit ratings of banks listed and unlisted on European exchanges.

Other research works have studied the reaction of markets to rating publications during crises. In this context, Ghachem (2015) conducted an event-driven study to determine the short-term impact of rating announcements for 207 U.S. firms during the 2008 global financial crisis. The study showed that investors lost confidence in rating agencies during the 2008 financial crisis. These agencies must increase the credibility of the information disclosed and review their methodologies for assigning and changing ratings. They must also be careful when valuing large companies that are of great interest to investors.

Rosati et al. (2020) examined the impact of changes in sovereign debt ratings on stock market prices in five countries during a financial crisis by proposing a new empirical approach based on Markov chains. The results show that the effects of ratings were highly significant for all countries. Some researchers have focused on examination of the impact of the country's credit ratings on sovereign bonds, specifically, on the cost of capital, which is measured by the credit default swap (CDS) premium. Chen et al. (2013) suggest that changes in sovereign ratings affect real macroeconomic outcomes, and physical capital investment plays an important role in determining a country's long-term growth rate.

In this framework, the study by Galil and Soffer (2011) found in general that CDS spreads change greatly following the announcement of rating changes and rating reviews. Nevertheless, variations in CDS spreads are larger around negative events than around positive events, which justifies the asymmetry of the market reaction to rating announcements.

Chodnicka-Jaworska (2016) and Binici et al. (2018) showed that financial markets react to changes in credit ratings. Indeed, the cost of capital in the capital markets changes when ratings are changed. Yang et al. (2017) showed that stock price reactions to downgrades are more statistically significant than upgrades. Avramov et al. (2009) validated the impact of rating changes on investor behaviour. They found that after the downgrades, strong institutional sales were observed and confirmed by the idea that sovereign credit ratings play a central role for investors in equity markets, improve the transparency of a market's credit risk profile and can therefore significantly influence investment flows in domestic equity and bond markets.

Others analysed contagion after ratings announcements. They focused on studying the interdependence of markets by examining both the permanent and transitory effects of sovereign credit ratings on the temporal correlations between stock and bond markets with their regional markets. In this regard, Christopher et al. (2012) observed that positive ratings lead to higher returns not only in the affected country, but also in the countries surrounding it. In contrast, during downturns, international equity investors tend to divert funds from the affected stock market to other stock markets in the region. Also, they found that co-movements in equity and bond markets within a region respond heterogeneously to sovereign ratings.

Zemirli (2022) identified the determinants of financial crises contagion in the euro zone by focusing on the spread of the Greek crisis triggered in 2010. He showed that the ratings published represented a transmission channel for sovereign CDS risk.

Other studies have shown negative effects of financial rating on the internationalization strategies of multinational firms (Lantin, 2012). However, after the 2008 financial crisis, some analysts suggest that rating agencies have contributed to financial crises, including the subprime crisis and the Asian crisis. They encourage agencies to increase the credibility of disclosures and to be cautious when evaluating large companies that are of great interest to investors (Darbellay & Partnoy, 2012; Moosa, 2017; Luitel et al., 2016; Dardour, 2013).

Despite many criticisms, the idea remains that rating agencies are likely to remain an important part of the infrastructure of modern financial systems (White, 2018).

In another research context, Abid's (2025) study, which aims to predict sovereign credit risk for Egypt, Morocco, and Saudi Arabia during political crises, revealed significant differences in their perceived creditworthiness, reflecting each country's economic fundamentals and their ability to manage global shocks, particularly those related to the Russia-Ukraine war. In the same vein, Moustafa and El-Shal (2025) examined the potential mispricing of sovereign risk in the MENA region. The results reveal distinct asymmetric herd behaviour in MENA debt markets, highlighting the treatment of MENA debt assets as a unified category.

To our knowledge, the impact of rating announcements on the stock markets of less-developed countries during times of crisis has not been really studied.

The frequent use of GARCH (Generalized Autoregressive Conditional Heteroskedasticity) models is due to the fact that financial data often exhibit conditional heteroskedasticity and non-normal distributions. To properly model this type of data, it is necessary to use a model capable of taking these characteristics into account. Our study explores an approach that is not based on simple observations, but on the analysis of the links that could exist between the change in ratings on the one hand and stock prices on the other hand.

Following our theoretical and empirical literature and the results of previous research, we analyse some hypotheses: the significance of abnormal returns (H1), the asymmetry of stock market reactions to different announcements (H2), and finally, inter-market interdependence (H3):

H1: Rating announcements influence the volatility of stock market returns.

H2: The reaction of stock market returns depends on the type of rating published: The market reacts more to downgrades than to upgrades.

H3: A change of rating in one country influences the volatility of stock markets in neighbouring countries in the same zone.

From an empirical point of view, we focus on the recent crises experienced by the MENA zone, in particular the health crisis and the political crisis, which represent two crises of different origins other than financial.

3. Data and Methodology

3.1 Stock market returns data

Stock market index returns data of the following 12 countries representing the MENA region were taken, namely Egypt, Tunisia, Morocco, Bahrain, Lebanon, Saudi Arabia, Kuwait, Oman, Qatar, Turkey, Jordan and the United Arab Emirates. Due to the non-availability of data, some MENA countries were withdrawn (Libya, Mauritania, Algeria, …). The data were collected from the Reuters DataStream database and the website investing.com[2].

3.2 The ratings

In the first step, we collected 109 rating announcements from the rating agency, Moody's, concerning the above-mentioned countries in the MENA stock market. The sources for the data are the websites of the rating agencies, however, due to the difficulty of accessing the websites of other rating agencies, rating data is only available from Moody's.

In the second step, we collected the ratings announcements of the countries selected in the sample for the study period. These announcements are categorized into three groups: negative ratings (downgrades), neutral ratings (affirmations), and positive ratings (upgrades). This classification allowed us to retain 109 announcements. Table 1 shows the descriptive statistics of the sample. According to the table, positive ratings represent 59% of the total number of ratings and neutral ratings represent 46%. Contrary, positive ratings are rare, representing only 4% of the total number of ratings.

Table 1: Descriptive statistics

Country	**Ratings announcements**		
	Negative ratings	Neutral ratings	Positive ratings
Tunisia	7	4	0
Morocco	0	6	0
Lebanon	8	3	0
Saudi Arabia	3	3	0
Kuwait	4	4	0

[2] www.investing.com.

Country	Ratings announcements		
	Negative ratings	Neutral ratings	Positive ratings
Egypt	10	8	2
Bahrain	6	3	0
Oman	9	2	0
Qatar	3	3	0
Turkey	7	3	2
Jordan	1	3	0
United Arab Emirates	1	4	0
Number	59	46	4
Total number		109	
Percentage	59%	46%	4%

Furthermore, for a given date *t* and a given country *i*, the dummy variables take the following values:

$$\text{Neutral rating}_{it} = \begin{cases} 1, \text{if a neutral rating occurs} \\ 0, \text{if not} \end{cases}$$

$$\text{Negative rating}_{it} = \begin{cases} 1, \text{if a negative rating occurs} \\ 0, \text{if not} \end{cases}$$

$$\text{Positive rating}_{it} = \begin{cases} 1, \text{if if a positive rating occurs} \\ 0, \text{if not} \end{cases}$$

3.3 Estimation technique

First, we will begin by measuring stock market volatility during the study period. To do this, we will adopt Nelson's (1991) EGARCH (1,1) model to capture volatility and asymmetry. But before proceeding with our analysis, we will first carry out some basic tests, namely descriptive statistics of endogenous variables, the heteroscedasticity test, the autocorrelation test and the correlation test.Next, we will perform stationarity tests (the Augmented Dickey-Fuller test; the Im, Pesaran, Levin, Lin test; and the PP-Fisher test), the Panel OLS model correlation tests, and model specification tests (Hausman test, 1978). Then, we will integrate discrete multiplicative variables into the conditional variance equation of our EGARCH model, which takes the value 1 if a change is announced and zero otherwise, and we will estimate the panel regressions.

Finally, we will examine the interdependence between stock markets. We divide the countries in our sample into two categories: Category 1 includes the border countries (Tunisia, Oman, Bahrain, Morocco, Lebanon, and Jordan) and category 2 includes the emerging countries that are neighbours of the same MENA region (Egypt, Kuwait, Qatar, Saudi Arabia, Turkey and United Arab Emirates).

This classification is compliant to a previous work, e.g. Afonso et al. (2012). Then, we will estimate the interdependence between stock markets due to changes in the ratings of countries in category 1 on the volatility of stock markets in countries in the category 2 and vice versa.

4. Results and Discussion

4.1 Stock market volatility during the study period

We present the results of the heteroscedasticity tests (Fisher's test), autocorrelation tests and correlation tests. Then, we present the results of the measurement of stock market volatility during the study period.

We first define stock returns at time t and for each country i, say r_t, as the difference between the logarithmic prices of the stock index at time t and t - 1. The yield series are generated as follows:

$$R_t = \text{LOG}\ (P_t/P_{t-1}) \tag{1}$$

where:

R_t is the yield at time t;

P_t and P_{t-1} are the closing prices of the indices at time t and t-1 respectively.

We adopt the EGARCH model proposed by Nelson (1991), who introduced the exponential GARCH, which is more useful than GARCH because it allows us to better specify the impact of different events on volatility. In fact, the EGARCH models state that negative and positive returns have different impacts on volatility, known as the asymmetric volatility phenomenon. For the EGARCH specification, we assume that the following model generates stock returns for each country i:

$$r_{i,t+1} = \mu_i + \varepsilon_{i,t+1} \quad (2)$$

$$\varepsilon_{i,t+1} = \sigma_{i,t+1} z_{i,t+1} \quad (3)$$

where:

$r_{i,t+1}$ are the continuous compound returns from time t to $t+1$ on the stocks of country i;

$z_{i,t+1}$ are distributed error terms with a mean of zero, scale one;

μ_i is the degree of freedom parameter that will be estimated from the data.

Finally, the volatility $\sigma_{i,t+1}$ of the returns $r_{i,t+1}$ is assumed to be given by the EGARCH (1,1) model of Nelson (1991), rewritten in a simpler way as:

$$\mathrm{Ln}(\sigma_{i,t+1}) = \omega_i + \beta_i \ln(\sigma_{i,t}) + \gamma_i z_{i,t} + \alpha_i(|z_{i,t}| - E|z_{i,t}|) \quad (4)$$

$z_{i,t} = \varepsilon_{i,t} / \sigma_{i,t}$ defines the standardized residuals.

α_i is the coefficient that captures asymmetric volatility phenomena, meaning that negative returns have a larger effect on volatility than positive returns of the same magnitude.

β_i is a parameter of the conditional variance (effect of the last period on the variance), this estimator indicates the persistence of the volatility.

γ_i is a coefficient that indicates the distinguishing effect between bad news and good news. The negative coefficient means that bad news has a larger effect on volatility.

According to authors Asai and McAleer (2011), equation (4) of the EGARCH (1,1) model volatility classifies this model in the case of models with standard skewness. In this case, the response of volatility to positive and negative return shocks is asymmetric: For positive return shocks, the slope is equal to $\gamma_i + \alpha_i$, and for negative return shocks, it is equal to $\gamma_i - \alpha_i$.

Moreover, if the coefficient α_i is positive and the coefficient γ_i is negative then a negative shock has a larger impact on volatility than the positive shock of the same magnitude, because $|\gamma_i - \alpha_i| \geq |\gamma_i + \alpha_i|$.

Results of the Heteroscedasticity test: Fisher's test

The heteroscedasticity test[3] results indicate values for the probability associated with the F-statistic that are below the risk threshold (5%) for the majority of the yield series, leading to the rejection of the null hypothesis and, consequently, the acceptance of the existence of the ARCH effect.

Results of the Autocorrelation test

The autocorrelation test results[4] indicate Durbin-Watson statistic values for all yield series that are close to two. Furthermore, the residual correlograms show that there is no problem with residual autocorrelation.

Results of the Correlation Test

The results[5] of the correlation test indicate weak correlation coefficients between the various indices. The values are all below 0.5 and too far from 1. All indices appear to be strongly uncorrelated with each other. The results can be explained in two ways: The first is that these stock markets are not very integrated or interconnected. The second is that the impact of the political and economic crisis generated by the Arab revolutions on all stock markets in the MENA region is transitory and its negative effects are clearly short-lived. Therefore, we accept the hypothesis that there was no correlation during the study period.

Results of the measurement of stock market volatility during the study period

Table 2 presents the results[6] of the measurement of stock market volatility during the study period. We present the results of EGARCH estimates[3] of volatilities for stock returns across the countries.

We find that, for most countries, the coefficients of the estimated EGARCH models are statistically significant. The values of the β_i estimates indicate high values of the coefficients that approach 1 with probabilities of statistical

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[3] Annex 1 contains the results of the ARCH effect test on variables.

[4] Annex 2 contains the autocorrelation test results for the yield series.

[5] Annex 3 contains the correlations between the various indices for the study period.

[6] Annex 4 contains the estimation results for the stock market volatility regressions.

significance of the estimated coefficients that are equal to zero. So, we show that volatility persists.

Table 2: Summary of EGARCH estimation results (equation (4))

Country	Asymmetry αi		Slope γ_i		Persistence βi			
	Coefficient	Prob	coefficient	Prob	coefficient	prob	$\gamma_i + \alpha_i$	$\gamma_i - \alpha_i$
Bahrain	0.634***	0.000	-10.103**	0.024	0.052	0.604	-9.469	-10.737
Egypt	0.030***	0.000	-0.199***	0.000	0.818***	0.000	-0.169	-0.229
Kuwait	0.364***	0.000	-0.230***	0.000	0.780***	0.000	0.134	-0.594
Lebanon	0.085***	0.000	0.005	0.428	1.012***	0.000	0.090	-0.080
Morocco	0.393***	0.000	-0.089***	0.005	0.793***	0.000	0.304	-0.482
Oman	0.423***	0.000	-0.198***	0.000	0.616***	0.000	0.225	-0.621
Qatar	0.385***	0.000	-0.138***	0.000	0.856***	0.000	0.247	-0.523
Saudi Arabia	0.212***	0.000	-0.268***	0.000	0.757***	0.000	-0.056	-0.480
Tunisia	0.256***	0.000	-0.059***	0.003	0.918***	0.000	0.197	-0.315
Turkey	0.281***	0.000	-0.040	0.329	0.469***	0.000	0.241	-0.321
Jordan	0.618***	0.000	-2.17	0.999	0.647***	0.000	-1.552	-2.082
United Arab Emirates	0.308***	0.000	-0.116***	0.000	0.880	0.000	0.192	-0.424

Note: This table shows the results of the EGARCH model estimation in (equation 4).

* p< 0.1; ** p< 0.05; *** p< 0.01.

The estimated coefficient α_i that captures the asymmetric effect of returns on volatility has positive values and is also statistically significant for most countries.

The volatility reaction to positive and negative return shocks is asymmetric: for positive return shocks, the slope is equal to $\gamma_i + \alpha_i$, and for negative return shocks, it is equal to $\gamma_i - \alpha_i$.

Moreover, if the coefficient α_i is positive and the coefficient δ_i is negative (which is the frequent case in our estimation results), then a negative shock has a larger impact on volatility than the positive shock of the same magnitude, because $| \gamma_i - \alpha_i| \geq | \gamma_i + \alpha_i|$.

a. The reaction of stock market volatilities to rating changes

In this section, we measure the impact of credit rating announcements on stock market volatility. To do this, we first carry out the necessary preliminary tests. Then, we use the exponential autoregressive generalized conditional heteroskedasticity (EGARCH) model developed by Nelson (1991). This model filters conditional volatility processes based on the specification of the conditional marginal distribution variable.

Finally, we incorporate multiplicative discrete variables into the conditional variance equation in our EGARCH model, which takes the value of 1 if a change announcement occurs and zero otherwise, and estimate the panel regressions as follows:

$$\text{Log}(\sigma_{i,t}) = \mu_i + \sum_{j=0}^{k} \lambda_j \text{negative ratings}_{i,t-j} + \sum_{j=0}^{k} \alpha_j \text{neutral ratings}_{i,t-j} + \sum_{j=0}^{k} \Phi_j \text{ positive ratings}_{i,t-j} \log(\sigma_{i,t-1}) + \zeta^T X_{t-1} + \varepsilon_{i,t} \quad (5)$$

where:

μ_i are the effects (fixed/random: to be demonstrated later) of country.

λ_j, α_j, and Φ_j are the coefficients of the dummy variables at the announcements of negative ratings, neutral ratings and positive ratings.

Finally, in the empirical application, $\sigma_{i,t}$ will be replaced by the conditional volatility filtered by the EGARCH (1,1) model according to equation (4).

Table (4) shows the estimation results of the stock market volatility regressions.

We present, in succession, the results of the preliminary tests and then the results of the estimates of stock market volatility regressions.

Results of the stationarity test

We performed the unit root test[7] to confirm the stationarity of the series of variables used. The ADF (Augmented Dickey-Fuller) test results show that the

[7] Annex 5 contains the results of the stationarity test.

variables in our model are stationary at level 1. The most common stationarity tests in the panel of Im, Pesaran, Levin, Lin, and the PP-Fisher test confirm the stationarity of the variable series. The results lead us to adopt an OLS panel model.

Results of the Panel OLS model correlation test

The correlation test[8] between variables shows that the correlation between variables is generally weak. However, the correlation between negative rating announcements and stock market volatility is the strongest (10.5%). These results show that rating downgrades affect stock market volatility more than neutral announcements and announcements of upgrades.

Result of the Hausman specification test

To estimate the presence of individual effects in the model, we performed the Hausman test[9] (Hausman, 1978). The hypotheses are as follows:

H0: stipulates the absence of correlation between the error term and the independent variables in the panel data model.

H1: stipulates the presence of correlation between the error term and the independent variables in the panel data model.

The results for the Hausman test are given in table 3.

Table 3: Hausman test results

Test Summary	Chi-Sq. Statistic	Prob
Cross-section random	10.875**	0.001

Note: ** $p< 0.05$

The value of the Hausman test probability is (0), which is well below the threshold used (5%). We must accept hypothesis H1, which stipulates the presence of correlation between the error term and the independent variables in the panel data model, and therefore favour the adoption of a fixed effects model.

[8] Annex 6 contains the results of the Panel OLS model correlation test results.
[9] Annex 7 contains the results of the Hausman test results.

Results of the estimation of stock market volatility in the fixed effects model

Table 4 shows the existence of asymmetric effects of rating changes on stock market volatility. Based on the results of the fixed effects model[10], we find that announcements of neutral ratings and announcements of positive ratings during the study period do not have a significant impact on stock market volatility. On the other hand, negative rating announcements have a significant impact on stock market volatility (p-value = 0 below the 1% significance level).

The results show that MENA stock markets during the crisis reacted strongly to announcements of negative ratings and did not react to announcements of neutral and positive ratings. These results are in line with those found in previous studies on the same issue (Ghachem, 2015; Chen et al., 2013; Yang et al., 2017; Binici et al., 2018; Rosati et al., 2020 and Mutize & Nkhalamba, 2020).

Thus, announcements of neutral ratings have no significant effect on volatility. Contrarily, negative rating announcements increase volatility.

Table 4: Results of the estimation of stock market volatility in the fixed effects model (equation (5))

	Dependent variable: Stock market volatility			
Independent variables	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000	0.000	1.20	0.230
Negative ratings	0.010	0.001	9.165***	0.000
Neutral ratings	0.000	0.001	0.201	0.840
Positive ratings	-0.002	0.005	-0.462	0.644

Note: *** p< 0.01.

b. The interdependence between stock markets

We examine the interdependence between stock markets by analysing the impact of rating changes announced by some countries on the volatility of other neighbouring countries in the same area.

In fact, the MENA zone encompasses the countries of North Africa and the Middle East. These countries do not have the same level of economic and

[10] Annex 8 contains the results of the estimation of stock market volatility in the fixed effects model.

financial development. Furthermore, according to the MSCI 2022[11] classification, some countries belong to the emerging countries category, others to the frontier countries category.

To analyse the interdependence between stock markets due to the influence of rating change announcements detected on stock markets, we divide the countries in our sample into two categories: Category 1 includes the border countries (Tunisia, Oman, Bahrain, Morocco, Lebanon and Jordan) and category 2 includes the emerging countries that are neighbours of the same MENA region (Egypt, Kuwait, Qatar, Saudi Arabia, Turkey and United Arab Emirates). This classification is compliant to previous works, e.g. Afonso et al. (2012).

Therefore, we estimate the following panel regression:

$$\text{Log}\,(\sigma_{i,t}) = \mu_i + \sum_{j=0}^{k} \lambda_j \text{ negative ratings}_{i,t-j}{}^{(1)} + \sum_{j=0}^{k} \alpha_j \text{neutral ratings}_{i,t-j}{}^{(1)} + \sum_{j=0}^{k} \Phi_j \text{positive ratings}_{i,t-j}{}^{(1)} + \sum_{j=0}^{k} \delta_j \text{negative ratings}_{i,t-j}{}^{(2)} + \sum_{j=0}^{k} \zeta_j \text{ neutral ratings}_{i,t-j}{}^{(2)} + \sum_{j=0}^{k} \varphi_j \text{positive ratings}_{i,t-j}{}^{(2)} + \beta \log(\sigma_{i,t1}) + \zeta^T X_{t-1} + \varepsilon_{i,} \quad (6)$$

where:

μ_i are (fixed/random: to be demonstrated later) country effects.

λ_j, α_j and Φ_j are the coefficients of the dummy variables of negative ratings, neutral ratings and positive ratings in category 1 countries, which are the border countries.

δ_j, ζ_j and φ_j are the coefficients of the dummy variables of negative ratings, neutral ratings and positive ratings in category 2 countries, which are the emerging countries.

In the empirical application, $\sigma_{i,t}$ in equation (6) will be replaced by the conditional volatility, filtered using the EGARCH (1, 1) model in equation (4).

In equation (6), the coefficients λ_j, α_j and Φ_j capture the contagion effects due to the downgrading and upgrading of border countries ratings, on the stock market volatility of emerging countries.

[11] MSCI: Morgan Stanley Capital International: https://www.msci.com/our-solutions/indexes/market-classification.

The coefficients δ_j, ζ_j and φ_j capture the contagion effects due to downgrades and upgrades of emerging market countries on the stock market volatility of border countries.

Table 5 presents the estimation results[12] for the stock market interdependence study.

Table 5: Estimation results of the stock market interdependence study (equation (6))

	Border countries		Emerging countries	
	Dependent variable: Stock market volatility			
Independent variables	t-stat.	prob.	t-stat.	prob.
Negative border country ratings (λ_j)	0.856	0.391	0.159	0.873
Neutral border country ratings (α_j)	-0.636	0.524	-0.051	-0.958
Positive border country ratings (Φ_j)	-	-	-	-
Negative Emerging Markets ratings (δ_j)	0.391	0.695	0.008	0.993
Neutral emerging market ratings (ζ_j)	-0.698	0.484	-0.094	0.924
Positive emerging market ratings (φ_j)	-0.284	0.776	-0.024	0.980

Based on the coefficient estimates and the corresponding t-statistics, we find, on the one hand, that the volatility of frontier stock markets does not react to the rating announcements of emerging countries of any kind. Also, it does not react to their own rating announcements.

On the emerging market side, emerging market stock market volatility does not react to either frontier or emerging market rating announcements of any kind.

In summary, in line with previous findings from the correlation test that showed that the correlation between rating change announcements and stock market volatility is too low in general, these results also point to a lack of interdependence between stock markets in the MENA region.

5. Conclusion

This study analysed the impact of rating change announcements on stock market volatility in the MENA region during a period of political, health and

[12] Annex 9 contains the estimation results of the stock market interdependence study.

economic turmoil associated with the outbreak of the Arab revolutions in many MENA countries as well as the severe health crisis of COVID-19. This deterioration led to a drop in investments, the disruption of financial markets and the downgrading of ratings. As a result, this area has experienced excessive negative changes in their ratings.

First, the measurement of stock market volatility during the study period yielded the following results: the values of the coefficient estimate of the EGARCH model showed the persistence of the volatility phenomenon during the study period in most countries. Also, they showed the asymmetry in the reaction of stock market volatility to different rating announcements. The effect of a negative shock was stronger than that of a positive shock. Our results corroborate those of Zaiane and Allita (2017), who showed that political risk is a factor explaining significant negative abnormal returns and stock market disruption.

Second, our results about stock market volatility reaction to rating change announcements showed that MENA stock markets during the crisis reacted strongly to negative rating announcements but did not react to neutral and positive rating announcements. These results are in line with the results found in previous studies. They are consistent with those obtained in previous studies on the same subject (Ghachem, 2015; Chen et al., 2013; Yang et al., 2017; Binici et al., 2018; Rosati et al., 2020; Mutize & Nkhalamba, 2020).

Third, we showed that the correlation between rating change announcements and stock volatility is too low in general and validated the lack of interdependence between stock markets in the MENA region (Christopher et al., 2012).

Our research may be useful for certain economic players. For rating agencies, the study showed the importance of the rating role for financial players, which pushes rating agencies to control the timeliness of publication and to ensure the quality of ratings to mitigate and reduce the effect of information asymmetry on financial markets and conflicts of interest. It also considers the specific characteristics of stock markets in less developed countries, which are less resistant to shocks and events.

For investors, we highlighted the informational role of ratings published on financial markets during crises, which represent a benchmark and a basic criterion on which an investor's investment decision is based. These results encourage companies and their managers to better guarantee the transparency and credibility of their ratings, to help investors make the right choice of shares and sector.

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Annexes

Annex 1: Results of the ARCH effect test on variables

	F-statistic	Prob.F
Bahrain	4.562**	0.033
Egypt	27.426**	0.000
Kuwait	0.105	0.744
Lebanon	0.015	0.900
Morocco	134.143**	0.000
Oman	9.127**	0.002
Qatar	47.154**	0.000
Saudi Arabia	70.077**	0.000
Tunisia	2.206	0.137
Turkey	18.747**	0.000
Jordan	0.0007	0.9776
United Arab Emirates	0.0801	0.0777

*Note:**** p< 0.01.

Annex 2: Autocorrelation test results for the yield series

	R-squared	Adjusted R-squared	Durbin-Watson stat
Bahrain	0.017	16.000	2.01
Egypt	0.012	0.010	1.998
Kuwait	0.009	0.008	2.003
Lebanon	0.000	-0.001	1.999
Morocco	0.022	0.020	2.03
Oman	0.019	0.018	1.972
Qatar	0.000	0.000	1.992
Saudi Arabia	0.003	0.001	1.95
Tunisia	1.000	1.000	1.823
Turkey	0.000	-0.001	1.999
Jordan	0.000	0.000	1.878
United Arab Emirates	0.000	0.000	1.804

Annex 3: Correlations between the various indices for the study period

	Bahrain	Egypt	Kuwait	Lebanon	Morocco	Oman	Qatar	Saudi Arabia	Tunisia	Turkey	Jordan	United Arab Emirates
Bahrain	1	0.0067	0.0604	-0.0154	0.1578	0.0313	-0.0124	-0.0267	-0.0521	0.1198	0.1421	0.2627
Egypt	0.0067	1	0.0476	-0.0009	0.0057	0.0680	0.0244	0.2106	-0.0228	0.0439	0.0186	-0.0138
Kuwait	0.0604	0.0476	1	0.0800	0.0271	0.0820	0.0899	0.1527	-0.0192	0.0321	0.0062	0.0311
Lebanon	-0.0154	-0.0009	0.0800	1	0.0190	0.0798	0.0202	0.0084	-0.0050	-0.0133	0.1343	0.0802
Morocco	0.1578	0.0057	0.0271	0.0190	1	0.0640	0.0373	-0.0129	0.0822	0.1357	0.0932	0.1002
Oman	0.0313	0.0680	0.0820	0.0798	0.0640	1	0.1288	0.0823	-0.0025	0.0904	0.1550	-0.0311
Qatar	-0.0124	0.0244	0.0899	0.0202	0.0373	0.1288	1	0.1798	0.0075	-0.0063	0.0306	0.0141
Saudi Arabia	-0.0267	0.2106	0.1527	0.0084	-0.0129	0.0823	0.1798	1	0.0091	0.0356	-0.0185	-0.0148
Tunisia	-0.0521	-0.0228	-0.0192	-0.0050	0.0822	-0.0025	0.0075	0.0091	1	-0.0305	0.0410	0.0160
Turkey	0.1198	0.0439	0.0321	-0.0133	0.1357	0.0904	-0.0063	0.0356	-0.0305	1	0.1514	0.0826
Jordan	0.1421	0.0186	0.0062	0.1343	0.0932	0.1550	0.0306	-0.0185	0.0410	0.1514	1	0.0825
United Arab Emirates	0.2627	-0.0138	0.0311	0.0802	0.1002	-0.0311	0.0141	-0.0148	0.0160	0.0826	0.0825	1

Annex 4: The results of the estimations (EGARCH)

Dependent Variable: BAHRAIN
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 04/06/23 Time: 14:14
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 36 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000226	0.000190	1.185266	0.2359
Variance Equation				
C(2)	-10.36144	1.038659	-9.975791	0.0000
C(3)	0.634576	0.051526	12.31563	0.0000
C(4)	-0.103417	0.045950	-2.250609	0.0244
C(5)	0.052057	0.100458	0.518201	0.6043

R-squared	-0.000093	Mean dependent var	0.000170
Adjusted R-squared	-0.000093	S.D. dependent var	0.005762
S.E. of regression	0.005762	Akaike info criterion	-7.594281
Sum squared res id	0.021612	Schwarz criterion	-7.559925
Log likelihood	2480.736	Hannan-Quinn criter.	-7.580957
Durbin-Watson stat	1.729195		

Dependent Variable: EGYPT
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 04/06/23 Time: 14:15
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 37 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	6.61E-05	0.000614	0.107709	0.9142
Variance Equation				
C(2)	-1.743228	0.214766	-8.116887	0.0000
C(3)	0.297752	0.036423	8.174731	0.0000
C(4)	-0.199836	0.023845	-8.380597	0.0000
C(5)	0.818935	0.025480	32.14025	0.0000

R-squared	-0.000206	Mean dependent var	0.000289
Adjusted R-squared	-0.000206	S.D. dependent var	0.015577
S.E. of regression	0.015578	Akaike info criterion	-5.607679
Sum squared resid	0.157987	Schwarz criterion	-5.573323
Log likelihood	1833.103	Hannan-Quinn criter.	-5.594355
Durbin-Watson stat	1.774444		

Dependent Variable: KUWAIT
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps) Date: 04/06/23 Time: 14:17
Sample: 1/07/2010 6/30/2022 Included observations: 652
Convergence achieved after 45 iterations
Coefficient covariance computed using outer product of gradients Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000462	0.000450	1.026515	0.3046
Variance Equation				
C(2)	-2.247868	0.345390	-6.508198	0.0000
C(3)	0.364243	0.035123	10.37063	0.0000
C(4)	-0.231101	0.029819	-7.750164	0.0000
C(5)	0.780655	0.037595	20.76514	0.0000

R-squared	-0.000921	Mean dependent var	0.000144
Adjusted R-squared	-0.000921	S.D. dependent var	0.010474
S.E. of regression	0.010479	Akaike info criterion	-6.417235
Sum squared resid	0.071482	Schwarz criterion	-6.382879
Log likelihood	2097.019	Hannan-Quinn criter.	-6.403911
Durbin-Watson stat	1.798614		

Dependent Variable: LEBANON
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps) Date: 04/06/23 Time: 14:18
Sample: 1/07/2010 6/30/2022 Included observations: 652
Convergence achieved after 74 iterations
Coefficient covariance computed using outer product of gradients Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000536	0.000187	-2.867733	0.0041
Variance Equation				
C(2)	0.081740	0.002997	27.27272	0.0000
C(3)	0.085707	0.008749	9.796492	0.0000
C(4)	0.005487	0.006929	0.791938	0.4284
C(5)	1.012986	0.000671	1509.706	0.0000

R-squared	-0.002971	Mean dependent var	-4.16E-05
Adjusted R-squared	-0.002971	S.D. dependent var	0.009069
S.E. of regression	0.009082	Akaike info criterion	-7.302942
Sum squared resid	0.053701	Schwarz criterion	-7.268586
Log likelihood	2385.759	Hannan-Quinn criter.	-7.289618
Durbin-Watson stat	1.998518		

Dependent Variable: MOROCCO
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 04/06/23 Time: 14:19
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 38 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000359	0.000231	1.556118	0.1197
Variance Equation				
C(2)	-2.405637	0.484468	-4.965526	0.0000
C(3)	0.393963	0.051726	7.616408	0.0000
C(4)	-0.089268	0.031946	-2.794397	0.0052
C(5)	0.793188	0.046052	17.22376	0.0000

R-squared	-0.002119	Mean dependent var	5.51E-05
Adjusted R-squared	-0.002119	S.D. dependent var	0.006606
S.E. of regression	0.006613	Akaike info criterion	-7.361020
Sum squared resid	0.028466	Schwarz criterion	-7.326664
Log likelihood	2404.693	Hannan-Quinn criter.	-7.347696
Durbin-Watson stat	1.697798		

Dependent Variable: OMAN
Method: ML - ARCH
Date: 09/20/22 Time: 14:38
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 25 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	-0.000146	0.000251	-0.580967	0.5613
Variance Equation				
C(2)	-4.145359	0.486288	-8.524500	0.0000
C(3)	0.423854	0.047558	8.912340	0.0000
C(4)	-0.198578	0.035360	-5.615929	0.0000
C(5)	0.616789	0.046788	13.18264	0.0000

R-squared	-0.000151	Mean dependent var	-0.000236
Adjusted R-squared	-0.000151	S.D. dependent var	0.007383
S.E. of regression	0.007383	Akaike info criterion	-7.161821
Sum squared resid	0.035488	Schwarz criterion	-7.127464
Log likelihood	2339.754	Hannan-Quinn criter.	-7.148497
Durbin-Watson stat	1.716001		

Dependent Variable: QATAR
Method: ML - ARCH
Date: 09/20/22 Time: 14:39
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 40 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000568	0.000344	1.650665	0.0988
Variance Equation				
C(2)	-1.617294	0.276570	-5.847689	0.0000
C(3)	0.385094	0.068931	5.586629	0.0000
C(4)	-0.138527	0.029890	-4.634494	0.0000
C(5)	0.856084	0.027436	31.20274	0.0000

R-squared	-0.000567	Mean dependent var	0.000307
Adjusted R-squared	-0.000567	S.D. dependent var	0.010991
S.E. of regression	0.010994	Akaike info criterion	-6.360996
Sum squared resid	0.078691	Schwarz criterion	-6.326639
Log likelihood	2078.685	Hannan-Quinn criter.	-6.347672
Durbin-Watson stat	1.939474		

Dependent Variable: SAUDI ARABIA
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 04/06/23 Time: 14:20
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 38 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000856	0.000397	2.157635	0.0310
Variance Equation				
C(2)	-2.393664	0.369098	-6.485175	0.0000
C(3)	0.212373	0.049253	4.311882	0.0000
C(4)	-0.268632	0.025429	-10.56394	0.0000
C(5)	0.757654	0.038048	19.91321	0.0000

R-squared	-0.001243	Mean dependent var	0.000465
Adjusted R-squared	-0.001243	S.D. dependent var	0.011095
S.E. of regression	0.011102	Akaike info criterion	-6.359112
Sum squared resid	0.080244	Schwarz criterion	-6.324756
Log likelihood	2078.071	Hannan-Quinn criter.	-6.345788
Durbin-Watson stat	1.880567		

Dependent Variable: TUNISIA
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 04/06/23 Time: 14:22
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 45 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000689	0.000181	3.797887	0.0001
Variance Equation				
C(2)	-1.026678	0.131399	-7.813456	0.0000
C(3)	0.256192	0.034273	7.475132	0.0000
C(4)	-0.059670	0.020464	-2.915870	0.0035
C(5)	0.918150	0.011207	81.92704	0.0000

R-squared	-0.002921	Mean dependent var	0.000356
Adjusted R-squared	-0.002921	S.D. dependent var	0.006161
S.E. of regression	0.006170	Akaike info criterion	-7.542938
Sum squared resid	0.024785	Schwarz criterion	-7.508582
Log likelihood	2463.998	Hannan-Quinn criter.	-7.529614
Durbin-Watson stat	1.818423		

Dependent Variable: TURKEY
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 04/06/23 Time: 14:23
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 29 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000905	0.000574	1.575786	0.1151
Variance Equation				
C(2)	-4.754571	1.174378	-4.048587	0.0001
C(3)	0.281272	0.063793	4.409149	0.0000
C(4)	-0.042615	0.043654	-0.976210	0.3290
C(5)	0.469307	0.135157	3.472308	0.0005

R-squared	-0.000039	Mean dependent var	0.000993
Adjusted R-squared	-0.000039	S.D. dependent var	0.014094
S.E. of regression	0.014094	Akaike info criterion	-5.702216
Sum squared resid	0.129322	Schwarz criterion	-5.667859
Log likelihood	1863.922	Hannan-Quinn criter.	-5.688891
Durbin-Watson stat	2.027029		

Dependent Variable: JORDAN
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 04/06/23 Time: 14:23
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 32 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000130	0.000193	0.676139	0.4990
Variance Equation				
C(2)	-4.162243	0.505994	-8.225873	0.0000
C(3)	0.618184	0.051451	12.01511	0.0000
C(4)	-2.17E-05	0.030983	-0.000701	0.9994
C(5)	0.647315	0.046825	13.82417	0.0000

R-squared	-0.000254	Mean dependent var	3.99E-05
Adjusted R-squared	-0.000254	S.D. dependent var	0.005681
S.E. of regression	0.005681	Akaike info criterion	-7.651448
Sum squared resid	0.021014	Schwarz criterion	-7.617092
Log likelihood	2499.372	Hannan-Quinn criter.	-7.638124
Durbin-Watson stat	1.877602		

Dependent Variable: UNITED ARAB EMIRATES
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Date: 04/06/23 Time: 14:24
Sample: 1/07/2010 6/30/2022
Included observations: 652
Convergence achieved after 31 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.000424	0.000452	0.939016	0.3477
Variance Equation				
C(2)	-1.283775	0.274985	-4.668524	0.0000
C(3)	0.308986	0.041641	7.420312	0.0000
C(4)	-0.116432	0.023689	-4.915054	0.0000
C(5)	0.880947	0.030024	29.34159	0.0000

R-squared	-0.000013	Mean dependent var	0.000378
Adjusted R-squared	-0.000013	S.D. dependent var	0.013021
S.E. of regression	0.013021	Akaike info criterion	-5.988148
Sum squared resid	0.110368	Schwarz criterion	-5.953792
Log likelihood	1957.136	Hannan-Quinn criter.	-5.974824
Durbin-Watson stat	1.804682		

Annex 5: The Results of the stationarity test

		Levin, Lin, Chu	Breitung-stat	Im, Pesaran Shin	Fisher–ADF	Fisher-PP
Stock market volatility	Stat.	-31.565	-17.028	-31.027	842.345	1964.950
	Prob	0.000***	-	0.000***	0.000***	0.000***
Negative rating announcements	Stat.	-68.405	-16.229	-40.618	1225.390	3160.690
	Prob	0.000***	0.000***	0.000***	0.000***	0.000***
Neutral rating announcements	Stat.	-68.370	-38.157	-40.431	1217.440	3160.690
	Prob	0.000***	0.000***	0.000***	0.000***	0.000***
Positive rating announcements	Stat.	-27.908	-15.070	-16.527	203.480	526.782
	Prob	0.000***	0.000***	0.000***	0.000***	0.000***

*** *$p < 0.01$.*

Annex 6: The Panel OLS model correlation test results

	Stock market volatility	Negative rating announcements	Neutral rating announcements	Positive rating announcements
Stock market volatility	1	0.105	0.001	0.000
Negative rating announcements	**0.105**	1	-0.010	0.050
Neutral rating announcements	0.001	-0.010	1	-0.002
Positive rating announcements	0.000	0.050	-0.002	1

Annex 7: The Hausman test results

Correlated Random Effects - Hausman Test
Equation: HAUSMANTEST
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	10.875007	1	0.0010

Annex 8: The Results of the estimation of stock market volatility in the fixed effects model

Dependent Variable: STOCK_MARKET_VOLATILITY
Method: Panel Least Squares
Date: 04/07/23 Time: 10:55
Sample (adjusted): 5/12/2010 6/29/2022
Periods included: 634
Cross-sections included: 12
Total panel (unbalanced) observations: 7587

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000146	0.000122	1.200570	0.2300
NEGATIVE_RATINGS	0.010095	0.001101	9.165654	0.0000
NEUTRAL_RATINGS	0.000281	0.001393	0.201858	0.8400
POSITIVE_RATINGS	-0.002428	0.005253	-0.462139	0.6440

Effects Specification

Cross-section fixed (dummy variables)

Root MSE	0.010467	R-squared	0.012718
Mean dependent var	0.000269	Adjusted R-squared	0.010892
S.D. dependent var	0.010534	S.E. of regression	0.010477
Akaike info criterion	-6.277314	Sum squared resid	0.831143
Schwarz criterion	-6.263605	Log likelihood	23827.99
Hannan-Quinn criter.	-6.272609	F-statistic	6.966966
Durbin-Watson stat	1.798837	Prob(F-statistic)	0.000000

Annex 9: The Results of the estimation of the interdependence between stock markets

Estimation of interdependence for emerging countries

Dependent Variable:
STOCK_MARKET_VOLATILITY_EMERGING_COUNTRIES
Method: Panel Least Squares
Date: 04/08/23 Time: 12:15
Sample (adjusted): 5/12/2010 6/29/2022
Periods included: 632
Cross-sections included: 6
Total panel (unbalanced) observations: 3785

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000464	0.000247	1.879869	0.0602
NEGATIVE_RATINGS_EMERGING_COU...	1.72E-05	0.002077	0.008303	0.9934
NEUTRAL_RATINGS_EMERGING_COUN...	-0.000262	0.002772	-0.094531	0.9247
POSITIVE_RATINGS_EMERGING_COUN...	-0.000187	0.007496	-0.024939	0.9801
NEGATIVE_RATINGS_BORDER_COUNT...	0.000358	0.002251	0.159026	0.8737
NEUTRAL_RATINGS_BORDER_COUNTR...	-0.000149	0.002869	-0.051943	0.9586

Effects Specification

Cross-section fixed (dummy variables)

Root MSE	0.014889	R-squared	0.001402
Mean dependent var	0.000465	Adjusted R-squared	-0.001244
S.D. dependent var	0.014901	S.E. of regression	0.014911
Akaike info criterion	-5.570590	Sum squared resid	0.839056
Schwarz criterion	-5.552459	Log likelihood	10553.34
Hannan-Quinn criter.	-5.564145	F-statistic	0.529986
Durbin-Watson stat	1.798697	Prob(F-statistic)	0.870131

Estimating interdependence for border countries

Dependent Variable:
STOCK_MARKET_VOLATILITY_BORDER_COUNTRIES
Method: Panel Least Squares
Date: 04/08/23 Time: 12:22
Sample (adjusted): 5/12/2010 6/29/2022
Periods included: 632
Cross-sections included: 6
Total panel (unbalanced) observations: 3787

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.99E-05	1.38E-06	36.05576	0.0000
NEGATIVE_RATINGS_EMERGING_COU...	4.56E-06	1.16E-05	0.391604	0.6954
NEUTRAL_RATINGS_EMERGING_COUN...	-1.09E-05	1.55E-05	-0.698872	0.4847
POSITIVE_RATINGS_EMERGING_COUN...	-1.20E-05	4.20E-05	-0.284571	0.7760
NEGATIVE_RATINGS_BORDER_COUNT...	1.08E-05	1.26E-05	0.856866	0.3916
NEUTRAL_RATINGS_BORDER_COUNTR...	-1.02E-05	1.61E-05	-0.636989	0.5242

Effects Specification

Cross-section fixed (dummy variables)

Root MSE	8.34E-05	R-squared	0.055108
Mean dependent var	4.99E-05	Adjusted R-squared	0.052606
S.D. dependent var	8.58E-05	S.E. of regression	8.36E-05
Akaike info criterion	-15.93916	Sum squared resid	2.64E-05
Schwarz criterion	-15.92103	Log likelihood	30191.79
Hannan-Quinn criter.	-15.93271	F-statistic	22.02259
Durbin-Watson stat	0.581754	Prob(F-statistic)	0.000000