Journal of Economic Integration
27(1), March 2012; 134-166

Testing for "Contagion" of the Subprime Crisis on the Middle East and North African Stock Markets: A Markov Switching EGARCH Approach

Wajih Khallouli
Ecole Supérieure des Sciences Economiques et Commerciales de Tunis- University

René Sandretto
GATE Lyon St Etienne

Abstract

In this paper, we investigate whether the recent financial turmoil which arose in the United States has contaminated the Middle East and North African countries (MENA). In contrast to Lagoard-Segot and Lucey (2009), we try to identify the existence of pure contagion (Masson, 1999) rather than shift-contagion (Rigobon, 2003). Then, we explicitly define financial "contagion" in accordance with Eichengreen et al. (1996) and we extend the Cerra and Saxena (2002) methodology by using a Markov-Switching EGARCH model introduced by Henry (2009) in order to identify contaminated MENA stock markets. Our results provide evidence of a persistence of recession characterised by low mean/high variance regimes which coincides with the third phase of the subprime crisis. In addition, there is evidence of mean and volatility contagion in MENA stock markets caused by the US stock market.

• **JEL Classification:** C32, F31, G01, G15

*Corresponding address: Wajih KHALLOULI; Ecole Supérieure des Sciences Economiques et Commerciales de Tunis- University of Tunis, 4 rue Abou Zakaria El Hafsi, 1089 MONTFLEURY (Tunisia), Tel: 216 71 330 266, Fax: 216 71 333 518, E-mail: wajih.khallouli@gmail.com / René SANDRETTO; GATE Lyon St Etienne (Groupe d'Analyse et de Theorie Economique) CNRS - University of Lyon, 93 chemin des Mouilles BP 167. 69131 ECULLY (France), Tel: 33 (0)4 72 86 61 12, Fax: 33 (0)4 72 86 60 90, E-mail: rene.sandretto@univ-lyon2.fr

• **Keywords:** Subprime Crisis, Contagion, MENA Stock Markets, Markov Switching EGARCH Model

I. Introduction

Over the last two decades or so, the Middle East and North African (MENA) countries such as many emerging and developing countries have made significant progress toward trade and foreign exchange liberalization. To a lesser extent, some of them have moved toward a greater integration into the international financial system. Some countries, namely Lebanon, and Yemen, are already at an advanced stage of trade liberalization and capital account convertibility. Others, such as Egypt, and Jordan have made progress in eliminating import and exchange restrictions, lowering import tariffs and adopting current account convertibility.[1] In recent years, the liberalization of inward capital movements has been pursued in most of these countries, together with a gradual relaxation of controls on outward capital flows. The reason for these policies was based on the general expectation that trade and financial liberalization would boost the economic activity by reinforcing competitiveness, opening new export markets, attracting foreign direct investment and stimulating savings and domestic investments. These reforms also paved the way for increased cooperation with developed countries, particularly with the European Union and the United States, leading sometimes to the conclusion of free trade agreements and even to association agreements. However, MENA countries still appear less integrated into international financial markets as compared to other emerging markets in Asia and South America. Many studies show that the MENA stock markets are not connected to developed financial markets (Yu and Hassan, 2006, Lagoarde-Segot and Lucy, 2007, Cheng *et al*., 2009).

However, nowadays there is no unanimous view about the consequences of this financial integration in emerging and developing countries. Some experts believe that financial liberalization produces unquestionably beneficial effects on growth and employment (Collins and Abrahamson, 2006), while others underline the fact that a wider integration into the international financial markets increases the vulnerability to foreign influences, particularly to reversals in international capital movements, which is generally referred to as the risk of "contagion". Therefore,

[1] The most comprehensive presentation of the strategies of trade liberalization in the MENA countries is given by Minot *et al*., 2010. In the particular case of Maghreb, see: Hufbauer and Brunel, 2008. See also: Mondher, 2011.

these countries are becoming more and more vulnerable to negative foreign shocks (see: Colins and Biekpe, 2003; Bekaert *et al*., 2005). The subprime crisis, for example, was not actually confined to the US mortgage markets. As a result of securitization, the crisis spread to the entire financial market, not only in the US, but also to all developed countries (Horta *et al*., 2008). Within a couple of months, the Dow Jones index plummeted from 14,093 (September 28, 2007) to 12,980 (November 23, 2007) and then to 6,626 (March 6, 2009). Similarly, the CAC40 nosedived from 6,168 (June 1, 2007) to 5,442 (August 15, 2007) and to 2,519 (March 9, 2008). In addition, Dooley and Hutchison (2009) and Lahet (2009) find that many emerging markets were affected by the global financial crisis after a first phase of resistance until the Lehman Brothers bankruptcy in September 2008.

In any case, due to the current financial crisis, there is growing concern in MENA countries regarding the risk of contamination. Although these countries are less financially integrated because of capital controls, or due to a poor access to international financing,[2] they may be contaminated by contagion caused by the cognitive convergence of domestic investors during the global financial turmoil as suggested by Lagoarde-Segot and Lucey (2009). Indeed, domestic investors in a mid-sized market could become jittery and opt for the minimum cost strategy, selling their stocks when they observe high volatility in the US stock market (Alper and Yilmaz, 2004). Our objective, in this paper, is to investigate a possible financial "contagion" of the financial crisis originated in the US on the emerging markets of the MENA region. Given the limited openness of MENA stock markets, rather than focusing on the stock market crisis, we try to analyze if the switch to periods of high volatility in MENA equity returns could be statistically explained by events in the US equity market during the subprime crisis of 2007-2009. More particularly, we examine if "contagion" occurs into countries which have poorly liberalized their financial system, as it is the case for some of them in the region.

The rationale of this paper is based on the following statement: while an abundant literature has been devoted to the current financial crisis, only a few publications try to identify a possible transmission to emerging markets (see: Dooley M. and Hutchison M., 2009). Among them, the MENA region is under-investigated despite the significant equity market development in the region since

[2]According to Lagoarde-Segot and Lucey (2007), MENA region is among the smallest attracting region of foreign investors (foreign capital represents 0.75% of GDP) compared with emerging countries.

the 1990s (Table 6 in appendix). The paper of Lagoarde-Segot and Lucey (2009) can be considered as an exception. The authors tried to reduce this gap using the battery of shift-contagion tests based on the correlation approach. However, this framework requires a consistently correlation between financial asset markets since it assumes the existence of interdependence according to the null hypothesis (Rigobon, 2003; Corsetti *et al*., 2005). In addition, in the MENA context, the interdependence with the US stock market seems unsubstantiated. In fact, using cointegration and causality tests, Neaim (2002), Soofi (2008) and Marashdeh and Shrestha (2010) show the absence of interdependence between MENA stock markets and developed stock markets and in particular the US stock market. Nevertheless, in this case, the correlation test is not the most appropriate for testing contagion. This analysis is too restrictive inasmuch as contagion and interdependence are mixed up. Obviously, there is no reason to assume that contagion can take place exclusively between strongly and permanently interdependent markets. In this paper, we refer to a more general concept in continuation of the approach suggested by Eichengreen *et al*. (1996). We define "contagion" as the increase in the probability of occurrence of a crisis in one country following the crisis in another country. Rather than shift-contagion of Rigobon (2003), our definition coincides with pure contagion of Masson (1999) that does not require the existence of interdependence between the origin country (ground zero country) and the affected country.

In order to examine the contagion of MENA stock markets from the US stock market, we apply a methodology based on the time-varying transition probability (TVTP) Markov-Switching approach (Cerra and Saxena, 2002). According to Chen (2009, 2010) and Henry (2009), this two regime switching model allows us to identify both bull and bear stock markets. The bull market is characterized by a high-mean, low-variance regime and it corresponds to the no-crisis period while the bear market is characterized by a low-mean, high-variance regime and it corresponds to the crisis period. Following Baur (2003), we consider two types of contagion: mean contagion and volatility contagion. The first is realised when changes in the US market returns affect the probability of switching between states (from bull market to the bear market) in one MENA stock market. Furthermore, we consider volatility contagion when the probability of switching from bull market to bear market in MENA stock market depends on the US stock market volatility.[3]

This paper contributes to the literature by investigating two important ways. On the one hand, we extend the Cerra and Saxena (2002) methodology using a two regime Markov-Switching Exponential GARCH model introduced by Henry (2009) which captures persistence in the conditional variance and asymmetry in stock volatility[4] within each regime rather than the simple Markov-Switching model.

On the other hand, our paper complements the study of Lagoarde-Segot and Lucey (2009) in which the shift contagion in the MENA stock markets has been examined using the correlation approach. Given that shift-contagion can be explained not only by shift in investor sentiment but also by endogenous liquidity shocks or political coordination (Forbes and Rigobon, 2001), our paper identify only the effect of the subprime crisis on the MENA stock markets sentiment using the Markov-Switching EGARCH approach. That is the main originality of our paper, since such an analysis has not been achieved up to this day in the context of MENA region.

The rest of the paper is organized as follows: section II presents different possible channels of transmission which can play a role in the case of emerging and developing countries. Section III describes the method that we use in order to identify "contagion". Section IV presents the data and our findings. Section V gives some concluding remarks.

II. Channels of "Contagion"

Before the 90's, the expression "contagion" was completely absent in the economic literature. It was only used in medicine, psychology and to a lesser extent in sociology and philosophy, with different meanings: "transmission by direct or indirect contact; the spread of a behavior pattern, attitude, or emotion from person to person or group to group through suggestion, propaganda, rumor, or imitation; the tendency to spread, as of a doctrine, influence, or emotional".[5]

Following the Asian crisis, it has become one of the most debated topics in

---

[3]In this case, changes in volatility of the US market increase the volatility in MENA market during a particular period of time. That is the volatility contagion of Baur (2003).

[4]Like the EGARCH, the GJR GARCH specification allows for identifying the asymmetry. In this article, we choose EGARCH because it is more flexible than the GJR GARCH avoiding us the use for the non-negativity constraints of the conditional variance.

[5]The Free Dictionary: http://www.thefreedictionary.com/contagion

international finance. However, among these recent financial publications, there is no consensus about what contagion really means (beyond a correlation of market returns) and about its mechanisms. In this abundant literature, some key questions have received a particular attention, namely:

- What are the channels through which crises spread across countries and markets?
- Are these channels stable through time or do they change specifically during crisis periods?
- In other words, are these channels specific to crises periods? Are these channels "crisis contingent" or not?[6]

A. Crisis non-contingent channels

Crisis non-contingent channels of propagation are characterized by the fact that there is no difference in the transmission mechanisms between crisis and tranquillity periods. In both cases, shocks are propagated along the same causality lines through linkages between countries, which can be either structural (and permanent) such as trade links[7] and financial links[8] or temporary.[9] This fundamentals-based "contagion" process can take three channels:

(1) Common shocks or monsoonal effect (Masson, 1999) are defined by simultaneous occurrence of crises in different countries which have similarities in macroeconomic policies and conditions. The contamination is caused by the incapacity of investors to discriminate between them after a common shock. This common shocks can result for example of a rise in the US or European interest rate or of a contraction in the international supply of capital.[10]

(2) Trade links are classified in two types of mechanisms: bilateral trade linkages and trade competition in third markets.

- The first one refers to the fact that a crisis in one country affects negatively its trading partners either as a result of a quantity effect (the diminution of the imports of the country in crisis shrink the outlets of its partners) or as a consequence of a price effect. For example, the devaluation/depreciation of the money of one

[6]As was first suggested by Forbes and Rigobon, 2001.
[7]See: Gerlach and Smets, 1995; Corsetti *et al.*, 1999.
[8]See: Kaminsky and Reinhart, 2000; Van Rijckeghem and Weder, 2003.
[9]See, for example: Masson, 1999, Calvo and Reinhart, 1996; Kaminsky and Reinhart, 1999.
[10]Forbes and Rigobon, 2001.

country causes a negative price effect in the trading partners (reduction of the import prices).[11]

In both cases, the trading partners can experience a harmful impact on their trade balance which may set up the domestic money of these countries for a speculative attack.[12]

- The second type of mechanism suggests that financial crisis can affect not only trading partners but also competitors which sell in the same third markets. For example, the depreciation/devaluation of the domestic money in one country reinforces its competitiveness which may influence negatively the situation of other countries competing in the same markets, creating a trade deficit for these countries and contributing thus to the transmission of the crisis to a broader range of countries.

(3) Financial links seem also to be a more and more important channel of "contagion" since emerging markets are increasingly integrated into global markets. When the stock prices are tumbling down in one country, referred to as the "ground zero" country (the first country to experience a crisis), international investors may decide to sell off assets not only in this country, but also in other ones, in order to rebalance their portfolios. Calvo (1999) underlines the fact that asymmetric information tends to amplify this portfolio rebalancing process. Logically, risk management techniques impose on investors the need to reduce their exposition in the most volatile and risky assets classes as well as credit lines in correlated markets. As a result, foreign banks will sell off loans and investments in other countries than the "ground zero" country, thereby spreading the crisis.

The loss of liquidity is also an important cross-border spillover mechanism. In case of a crisis in one country, the percentage of non-performing loans for foreign creditor banks will rise as the probability of repayment decreases. As a result, foreign banks increase provisions for bad loans, and eventually, need to recapitalize. Thus, they may withdraw their investments from other countries.[13]

B. Crisis contingent channels of propagation

In this second approach, investors behave differently during a crisis, activating temporary channels which add to or substitute for the permanent channels of

---

[11]See for example: Reside Jr and Gochoco-Bautista, 1999.
[12]Hail and Pozo, 2008; Van Rijcheghem and Weder, 2001.
[13]See: Kaminsky and Reinhart, 2000; Van Rijckeghem and Weder, 2001.

propagation. This phenomenon is sometimes described as either "shift-contagion" or as "pure contagion". Shift contagion occurs when interdependencies between pairs of markets increase above its normal level or become unstable during a crisis, while pure contagion involves a transmission process that is not explained by market fundamentals or by common shocks and which activates channels that could not have been identified before the crisis.[14] Pure contagion is generally the consequence of changes in investors' attitudes caused by financial panic and/or by the sudden perception of risks, leading to herding behaviors or switches of expectations.[15] By contrast to shift-contagion, pure contagion is only active during periods of external stress and does not require the preexistence of channels of market interdependence.

C. What about MENA countries?

In the case of MENA countries, given their limited financial integration with developed countries, pure contagion due to switches of expectations of domestic investors seems more plausible than shift contagion.

For MENA countries, these two kinds of channels (non-crisis contingent channels vs. crisis contingent channels) can play a role, even though the first one seems more plausible, in as much as their financial markets are relatively small with a low volume of transaction and few listed companies, compared to developed markets (see table 7 in appendix).

In this paper, we refer to Eichengreen *et al*. (1996), who consider "contagion" as the increase in the probability of crisis' occurrence in one country after the occurrence of a crisis in another country. This definition allows us to identify pure contagion as one of the crisis contingent channels (Forbes and Rigobon, 2001) from the US to MENA countries during the subprime financial crisis 2007-2009.[16] We focus our analysis on the stock market evolution. Identifying pure contagion is useful for both economic authority and international investors. For governments, it is necessary to correctly identify pure contagion in order to deal with it. In the presence of pure contagion, policies such as capital movement restrictions aimed at breaking or relaxing market linkages are unlikely to be successful. A better policy

[14]For an overview of the various definitions of contagion, see Pericoli and Sbracia (2003) and Dungey and Tambakis (2005). See also : Flavin and Panopoulou, 2010.

[15]See: Masson, 1999; Flavin and al, 2008.

[16]Obviously, testing other forms of contagion is nonetheless useful for a thorough understanding of the mechanisms that can affect MENA countries. It will be a topic for future research.

would be to adopt decisions aimed at reinforcing at reducing country specific risks and reinforcing its attractiveness. Actually, bringing herding behaviours of domestic investors under control is a key aspect of MENA authorities (as well as in any other countries) in order to contain the financial crisis.

In addition, given the sharp fall of equity markets in developed countries during the subprime crisis, testing for pure contagion can provide more information on the segmented MENA equity markets to investors, bankers and portfolio managers.

III. Identifying "Contagion" Methodology

How we can identify "contagion"[17]? Several different procedures, methodologies and techniques have been developed during the last 12 years. Most of them use the Probit/Logit methodology (Eichengreen *et al*. 1996; Glick and Rose, 1999; Caramazza *et al*. 2004). However, Cerra and Saxena (2002) used the Markov Switching approach to model the nonlinear behaviour of the crisis index without a need to transform it into a binary variable as it is the case in the qualitative models (probit or logit models).[18] According to Abiad (2003), this transformation is based on the choice of a crisis index threshold which differentiates the tranquillity and crisis periods. Of course, such a preliminary choice is obviously arbitrary. Besides, it generates a loss of information with the possibility of uncaptured crises periods (Mariano *et al*. 2004). Following the above cited literature we apply the Markov Switching Regime Model (MSRM) to avoid these drawbacks.

By contrast to the currency crisis, in stock market context, the MSRM is not frequently used to identify contagion. To the best of the authors' knowledge, Cerra and Saxena (2002) are the only exceptions. In this study, we extend the Cerra and Saxena methodology using the MS-EGARCH(1,1) model introduced by Henry (2009). He modifies the EGARCH specification[19] to account for such structural changes in the mean and variance terms using unobserved states $S_t \in \{0, 1\}$. According to Chen (2009), $S_t = 0$ indicates the low-mean, high-variance regime (bear market) which corresponds to crisis regime and $S_t = 1$ the high-mean, low-

[17] In order to clarify the terminology, we think that it would be better to use the word "contagion" for pure form of "contagion" (as described originally by Masson, 1999), or for crisis-contingent mechanisms of contamination, or for crises based on herding behaviors of investors.

[18] Which are also used in the crisis EWS literature (e.g. Kamin *et al*. 2001).

[19] The linear EGARCH model was introduced by Nelson (1991) and proposed a positive conditional variance without need for non-negativity constraints as it is the case in the estimation of GARCH models.

variance state (bull market) which corresponds to stable regime. The S_t process is assumed to follow a Markov chain of order one. Its transition probability matrix P is given by:

$$P = \begin{pmatrix} p_{00} & p_{01} \\ p_{10} & p_{11} \end{pmatrix} \tag{1}$$

where p_{ij} represents the probability[20] that state j at time t-1, will be followed by state i at time t:

$$p_{ij} = \Pr(S_t = i / S_{t-1} = j) \forall i, j = 0, 1 \tag{2}$$

Therefore, the following equalities hold:

$$\begin{aligned} p_{00} + p_{10} &= 1 \\ p_{01} + p_{11} &= 1 \end{aligned} \tag{3}$$

The MS-EGARCH model used in this paper is given by:

$$\psi(L) R_t = \mu_{S_t} + e_t \tag{4}$$

$$e_{t \sim} iidN(0, h_{s_t}) \tag{5}$$

$$\log(h_{S_t}) = \omega_{S_t} + \alpha_{S_t}\left[\left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi}\right] + \beta_{S_t}\log(h_{S_{t-1}}) + \delta_{S_t}\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \tag{6}$$

where 'R_t' represents the return on one stock market index between time t-1 and t, e_t is the error term for the return at time t, $\psi(L)$ is the lag operator and μ is the intercept term. Eq.(4) refers to the conditional mean in which intercept is allowed to switch between a high mean returns μ_1 and a low mean returns μ_0. In addition, Eq.(6) allows us to model the conditional variance of R_t for a high volatility regime h_0 and the low volatility regime h_1. It ensures the positive conditional variance and accounts for the leverage effect.[21] That is coefficients δ_0 and δ_1 that allow capturing asymmetric respond of conditional variance to shock ε_t of either sign for two

[20]The transition probabilities, which are assumed to be constant over time, are specified by the logistic functional form (cf. Henry, 2009).

[21]When a negative shock generates more volatility than a positive shock of equal magnitude.

regimes high/low volatility, respectively.

According to Cai (1994) and Hamilton and Susmel (1994), the autoregressive term h_{t-1} in Eq.(6) leads to a path-dependent structure difficulty. In this case, maximum likelihood estimation of the model is computationally intractable because the conditional variance h_t depends on the entire past history of unobserved regimes. Following Gray (1996) and Henry (2009), we adopt an approximation measure of h_{t-1} in Eq.(6) to avoid the path dependent problem. Using the information observable at time t–2, the conditional expectation of the past variance is given by:

$$\begin{aligned} h_{t-1} = E_{t-2}[h_{S_{t-1}}] &= p_{11}(\mu_{1,t-1}^2 + h_{1,t-1}) + (1-p_{11})(\mu_{0,t-1}^2 + h_{0,t-1}) \\ &-[p_{11}\mu_{1,t-1} + (1-p_{11})\mu_{0,t-1}]^2 \end{aligned} \tag{7}$$

Using (7) in place of h_{t-1} in Eq.(6), implies that each conditional variance is depending only on the most recent regime and not on the entire history of the process (Henry 2009).

The chief objective of this study is to identify the "contagion" effect of the US subprime crisis to the MENA stock markets. To this end, we first test the superiority of the Markov switching model with transition probabilities varying over time. Then, we go further by adopting time-varying transition probabilities (TVTP) depending on z_t in the benchmarking MS-EGARCH model. In order to detect the US subprime crisis, we consider first the negative shocks of the US stock markets return when z_t decreases. In this case, using the TVTP allows us to test whether a fall in the US stock market return (z_t) influences the probabilities of a change from the bull market to the bear market in the MENA countries. Such an impact would clearly identify a contagion process. Following Baur (2003), this type of contagion is qualified by "mean contagion". In addition, according to Baur (2003), crises periods could be identified by an increase in volatility which characterises a greater uncertainty. When this volatility has a significant effect on the conditional volatility of other stock markets, then there is evidence of a volatility spillover (Edwards, 1998). However, Baur (2003) distinguishes between volatility spillover and volatility contagion. He supposes that the effect of a volatility increase in one market on the conditional volatility of another stock market takes place only during crises periods. In contrast, volatility spillover can occur at any time. Then, the TVTP allows us to conceptualize the notion of volatility contagion as a significant effect of the volatility increase in the US stock market on the switching regime of conditional volatility of MENA stock markets. Testing both mean contagion and volatility contagion allow us to identify all types of negative effects of the US subprime crisis on the MENA stocks markets since mean contagion is not necessarily associated with the volatility contagion (Baur, 2003).

Thus, following Diebold *et al*. (1994), the time-varying transition probabilities may be written:

$$p_{00}^{t} = \Pr(s_t = 0/s_{t-1} = 0) = \frac{\exp(\theta_0 + \theta_1 z_{t-1})}{1 + \exp(\theta_0 + \theta_1 z_{t-1})} = 1 - p_{10}^{t} \quad (8)$$

$$p_{11}^{t} = \Pr(s_t = 1/s_{t-1} = 1) = \frac{\exp(\lambda_0 + \lambda_1 z_{t-1})}{1 + \exp(\lambda_0 + \lambda_1 z_{t-1})} = 1 - p_{01}^{t} \quad (9)$$

where p_{10}^{t} (p_{01}^{t}) represents the probability of switching from the high-mean, low-variance (low-mean high-variance) state to the low-mean high-variance (high-mean low-variance) state in the next period. The equalities given by equations (3) always hold. In our analyse, z_t is the US stock market returns or volatility. Note that following Filardo (1994), we lagged z_t to ensure they are strictly exogenous and must be conditionally uncorrelated to the unobserved state. In order to investigate whether fluctuations in the US stock market influence the probabilities of a change in regimes in the MENA stock markets, we test the null hypothesis of $\lambda_1 = \theta_1 = 0$ using the likelihood ratio *LR* statistic suggested by Filardo (1994). Once the null hypothesis is rejected, we analyze then the marginal effect of z_{t-1} on p_{ii}^{t} for $i = 0,1$ which, according to Filardo (1994), are given by:

$$\frac{\partial p_{00}^{t}}{\partial z_{t-1}} = \theta_1 p_{00}^{t}(1 - p_{00}^{t}) \quad (8)$$

$$\frac{\partial p_{11}^{t}}{\partial z_{t-1}} = \lambda_1 p_{11}^{t}(1 - p_{11}^{t}) \quad (9)$$

Since the transition probabilities p_{00}^{t} and p_{11}^{t} are non-negative and range between zero and one in magnitude, then the marginal effects $\partial p_{11}^{t}/\partial z_{t-1}$ and $\partial p_{00}^{t}/\partial z_{t-1}$ have the same sign of λ_1 and θ_1.

Clearly $p_{10}^{t} = (1 - p_{11}^{t})$ is the probability of switching from bull market (high-mean low-variance state) to bear market (low-mean high variance) state. Therefore, for $\hat{\lambda}_1 > 0$ a negative shock to US stock market returns implies that the equity returns of MENA country are more likely to switch to the bear market regime. In addition, $\hat{\lambda}_1 < 0$ implies that the probability of switching to the bear market regime increases following a positive shock in US stock market volatility. In both cases we interpret result as volatility and/or mean contagion effect from the subprime crises to the MENA stock markets.

Like Hamilton (1989) and Diebold *et al.* (1994), we estimate our Markov switching EGARCH model with the fixed transition probabilities or with the time-varying transition probabilities using the maximum likelihood method.

IV. Data and Empirical Results

A. Data description and GARCH approach

To identify the MENA 'bear market phases' during the global financial crisis, daily closing stock market index prices from nine countries are examined in this study. We consider the Gulf Cooperation Council (GCC) countries namely Oman (OMA), Bahrain (BAH), Kuwait (KUW) and Dubai (DUB) and non GCC countries, such as Morocco (MOR), Egypt (EGY), Turkey (TUR) and Jordan (JOR). In addition, to investigate the "pure contagion" from the US stock market, we base our analysis on the SP&500 of the US stock market index price as "ground zero" country. All indices are denominated in US dollars. This allows us to capture the point of view of the international investors. The stock market assets returns are calculated as follows: $r_t = 100\times\ln(I_t/I_{t\text{-}1})$, where I_t is the stock price on the date t. The data are sampled over the period from February 20, 2007 to March 31, 2009, for a total of 551 observations. All data are extracted from the Datastream database. We use daily return series because they contain enough numbers of observations over a crisis period (Cerra and Saxena, 2002). In addition, the sample period contains only the subprime crisis windows starting with the first phase in February 2007 (Dooley and Hutchison, 2009).

Table 1 provides the cross-market correlations with the US stock market and some descriptive statistics for all of the countries analyzed.

As shown in the first column in Table 1, most of the correlation coefficients between the SP500 stock market index return and MENA cross-market seem excessively low. The higher correlation is with Turkey (0.416). As expected, this

Table 1. Correlations with the US stock market and descriptive statistics.

	Correlation	Mean	Median	Maxi-mum	Mini-mum	Std. Dev.	Skewness	Kurtosis	J-B	$LB^2(12)$
OMA	0.0337	-0.0383	0.0053	8.0395	-8.6973	1.8131	-0.8129	9.5480	1045.07***	453.36***
BAH	0.0168	-0.0538	-0.0084	2.6723	-3.7163	0.7113	-0.9245	7.2947	501.95***	197.11***
KUW	-0.0007	-0.0934	0.0060	4.8062	-8.3003	1.3561	-0.7406	7.8075	580.99***	246.47***
DUB	0.1025**	-0.1805	-0.0116	10.218	-8.8196	2.1750	0.1120	8.0239	580.63***	451.39***
MOR	0.0756*	-0.0118	0.0121	6.1258	-6.4807	1.3631	-0.3616	7.0020	379.71***	154.53***
EGY	0.1752***	-0.0813	0.0889	5.7576	-17.494	1.9085	-2.0715	17.281	5076.86***	76.075***
TUR	0.4169***	-0.1328	-0.0346	15.852	-14.761	3.1860	-0.1575	6.1877	235.57***	119.21***
JOR	0.007	-0.0223	0.0000	4.7014	-4.7229	1.4110	-0.2757	4.3417	48.31***	522.43***
US	-	-0.1079	0.0000	11.042	-9.5137	2.0635	-0.0996	0.4505	682.96***	516.74***

Note: * denote statistical significance at 10%. ** denote statistical significance at 5%.
*** denote statistical significance at 1%.
J-B is the statistic of Bera and Jarque (1980) normality test.
$LB^2(12)$ is the Ljung-Box test for squared returns with 12 lags.

result confirms that there is not a clear interdependence between the US and the MENA stock markets of our sample. In addition, table 1 shows that Turkish and Dubai stock markets have the highest volatility. For these countries, the standard deviation is respectively equal to 3.186 and 2.175. All countries are associated with a negative average return. Skewness and Kurtosis coefficients of the different series indicate a deviation from the normality assumption. Results of the J-B test show that the null hypothesis of normal distribution is significantly rejected for all stock markets returns.

Since we use the daily frequency, our data could be affected by volatility changes over time and volatility clustering (Brunetti *et al*., 2008). Figure 1 in appendix of squared returns could show it. The Ljung-Box (1978) statistic reported in the last column of Table 1, shows that the null hypothesis of uncorrelated squared returns for all countries, is rejected. This result confirms evidence of volatility clustering (Caporale *et al*., 2006) and consequently the presence of conditional heteroscedasticity effect (Bollerslev, 1986). More formally, P-values results of the LM and the LB^2 of linear AR(1) model in table 2, confirm the strong evidence of ARCH effect in the standardized residuals. All these findings motivate the use of the GARCH approach for capturing the volatility clustering phenomenon. Following Henry (2009), we estimate for each of our MENA stock markets returns a simple AR(1)-EGARCH (1,1) model. This last one also allows the capture of the asymmetry in volatility generated by the leverage effect when a large price increase or a sharp price drop affects differently the volatility (Khedhiri and Muhammad, 2008). The results reported in table 2, show that both the LM and the LB^2 tests succeeded in rejecting the ARCH effect for all series except for Jordan that presents a significant autocorrelation for the squared residuals. On the other hand, our EGARCH model captures the asymmetry in the volatility given the negative and significant $\hat{\delta}$ for the majority of countries. All these findings motivate the use of the EGARCH approach for modelling the Markov switching model.

B. Global financial crisis diagnostics for MENA countries: MS-EGARCH model with fixed transition probabilities

We use the likelihood ratio (LR) tests in order to test the null hypothesis which is the linearity of our EGARCH model. The alternative hypothesis is the Markov-switching EGARCH model. Although the GARCH approach is able to capture the clustering volatility and/or asymmetry in volatility, it fails to capture structural shifts in the data caused by international financial crises (Edwards and Susmel, 2001). The LR test allows us thus to identify the structural break or switch between the two regimes (stability and crisis) during the subprime turmoil period (2007-2009). However, as noted by Davies (1977), there are nuisance parameters under the null hypothesis since the transition probabilities are unidentified (Henry, 2009). Then, the *LR* statistic $LR = 2(\log(L_{MS}) - \log(L_{linear}))$ has a non-standard asymptotic distribution. Therefore, it seems more judicious to adopt the Davies (1977) upper bound approach as suggested by Garcia and Perron (1996). Assuming that the likelihood ratio has a single peak, the P-values of the upper bound on the $\chi^2(5)$[22] statistic[23], are then calculated. The results, reported in table 3, support the rejection of the null hypothesis (the linearity of the model) at a significant level of 5% for all series with the exception of Jordan stock markets. Our result for Jordan is more difficult to explain. However, the lower liquidity levels and higher sectoral concentration of the Jordan stock market compared to the non GCC countries of our sample (Lagoarde-Segot and Lucy, 2009) could be a part of the explanation for the Jordanian stock market immunity.

Therefore, we can conclude that the MS-EGARCH has identified the regime shifts in the majority of the MENA stock markets. To be more precise, with the

[22]In our case, the number of degrees of freedom is equal to 5 which is equivalent to the additional parameters appearing in the Markov-switching EGARCH model to the EGARCH model.

[23]We assume that the likelihood ratio has a single peak. P-value is given as $\Pr(\chi^2 > LR) + 2(LR/2)^{D/2} \exp(-LR/2)/\Gamma(D/2)$ where D=5 parameters and $\Gamma(.)$ is the gamma function.

exception of Jordan, our results provide evidence that the MENA stock markets have been affected by the global financial crisis and obviously switched from the "bull market" with a higher return and lower variance to "bear market" characterised by low-return volatility. As shown in table 3, we notice that for all countries affected by the global financial crisis, average returns for the regime 0, are substantially lower than those of regime 1. In contrast, it is clear that unconditional variances for regime 0, are substantially higher than those of the regime 1. In fact, daily return for stable regime μ_1 ranges from 0.033% to 0.221% while daily return depreciation during crisis regime jumps to 1.201% for the Dubai stock market. In addition, in regime 1, the value of the conditional variance intercept' ω_1 is between -1.244 and 0.779, whereas, in crisis regime, ω_0 is around 0.301 to 1.655 in the Turkey stock market, implying a relatively high level of unconditional volatility for all affected countries. Additionally our results find evidence of an asymmetric effect of negative news on conditional volatility during both the crisis regime and the stable regime. Indeed, for all affected countries, the values of $\hat{\delta}_0$ are negative and are significantly different to zero, implying that negative innovations to returns have a bigger impact on volatility than positive innovations of equal size. In addition, except for Kuwait for which $\hat{\delta}_1$ is positive and is not statistically significant, the asymmetry is verified also during the stable regime since $\hat{\delta}_1$ is negative and significantly different to zero for all remaining affected counties. Even during the stable period, these markets react with more volatility to negative shocks than to positive shocks of equal size. Moreover, $\hat{\beta}_0$ is significantly different to zero for all affected stock markets. This result shows the persistence in conditional volatility caused by the persistence of shocks arriving in crisis regimes.

Table 3 also reports the unconditional probabilities of two regimes. The unconditional probability p_{11} of being in regime 1, characterized by a higher return and a lower volatility, ranges between 96.5% for Bahrain and 98.3% for Morocco. This means that there is a lot of persistence in the no-crisis state for MENA stock markets during the subprime crisis. On the other hand, the unconditional probability p_{00} of staying in a crisis regime with low-return volatility seems smaller than the probability of remaining in regime 1. However, p_{00} ranges between 86.7% for the Bahrain stock market and 96.6% for the Morocco stock market. The expected duration of crisis regime is between 8.06 days for the Bahrain stock market and 29.41 days for Morocco. The second higher persistence of staying in crisis regime is about 20 days for the Turkey stock market. According to Ismail and Isa (2008), the small persistence of regime 0 compared to the persistence of regime 1, implies that only extreme events can switch the MENA stock markets from a stability characterized by a bull market to a crisis situation characterized by a bear market.

Figure 2 in appendix exhibits the smoothed probabilities[24] of being in the crisis regime (bear market) using MS- EGARCH estimations. Analysing these smoothed probabilities, it is clear that our model was able to identify both the resistance phase and the failure phase of emerging market discussed by Dooley and Hutchison (2009) and Lahet (2009).

As shown in Figure 2 in appendix, a first period from February 2007 to September 2008, could be identified for all countries except for Turkey. This period is characterized by the shorter bear market regimes between one- and three-day which could not reflect the crisis period. According to Dooley and Hutchison (2009), these shocks during this first resistance phase, could be explained by the fall in oil prices for GCC countries and the fall of international commodity prices. In contrast to other MENA countries, the Turkey stock market has reacted clearly to the burst of US mortgage bubble in august 2007. The Turkish smoothed probability can identify a long bear market from July 19, 2007 to August 22, 2007.

The smoothed probabilities (Figure 2 in appendix) identify also a second phase of MENA stock markets failure from August 2008. This second phase is apparent by a persistent of the long bear market which has appeared clearly since September 2008 that seems to coincide with the Lehman bankruptcy and then financial instability on a worldwide level.

C. Identifying the US subprime "contagion" to MENA stock markets: MS-EGARCH with time varying transition probabilities

As noted earlier, the use of the TVTP assesses the impact of the US subprime crisis on the MENA stock markets. Our purpose is to investigate whether the dynamic phases of MENA stock returns, which show a relative coincidence with the third phase of the subprime crisis, are affected by a fall in the US stock market returns (mean contagion) or/and a volatility increase in the US stock market returns (volatility contagion). To this purpose we test, as a first step, for significance of the

[24]Contrary to the filtered probability that is estimated using information available at time point t, the smoothed probability is estimated using full sample information to determine switch occurrences between the unobserved regimes. Following Hamilton (1989), smoothed probability allows to capture the turning points when it is greater than 50%.

Table 2. Estimation results of AR(1)-EGARCH (1,1).

	Oman	Bahrain	Kuwait	Dubai	Morocco	Egypt	Turkey	Jordan
μ	-0.042	-0.017	-0.0003	-0.126	0.032	0.044	-0.0007	0.020
	(0.043)	(0.024)	(0.039)	(0.033***)	(0.041)	(0.05)	(0.001)	(0.003***)
ω	0.102	-0.119	0.017	0.170	0.032	0.027	0.375	0.032
	(0.023***)	(0.048***)	(0.01*)	(0.007***)	(0.014***)	(0.011***)	(0.015***)	(0.011***)
α	0.344	0.247	0.210	0.349	0.316	0.096	0.282	0.309
	(0.059***)	(0.057***)	(0.054***)	(0.007***)	(0.051***)	(0.021***)	(0.048***)	(0.042***)
β	0.894	0.850	0.943	0.871	0.931	0.962	0.821	0.945
	(1.942)	(2.185)	(5.578)	(0.05***)	(4.687)	(5.288)	(0.035***)	(0.034***)
δ	-0.139	-0.147	-0.147	-0.121	-0.069	-0.177	-0.209	-0.038
	(0.04***)	(0.053***)	(0.029***)	(0.184)	(0.032***)	(0.022***)	(0.026***)	(0.025)
LogLik	- 927.84	- 526.24	- 819.89	- 1091.73	- 856.63	- 1017.03	- 1369.45	- 858.17
	(0.999)	(0.768)	(0.561)	(0.202)	(0.198)	(0.769)	(0.226)	(0.942)
LM Test[a]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.043]	[0.1]	[0.000]
	(0.983)	(0.002)	(0.703)	(0.009)	(0.519)	(0.850)	(0.348)	(0.307)
LB(12)[b]	[0.232]	[0.021]	[0.495]	[0.159]	[0.003]	[0.217]	[0.147]	[0.298]
	(0.999)	(0.392)	(0.393)	(0.634)	(0.540)	(0.991)	(0.812)	(0.04)
$LB^2(12)$[b]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]

Note: *, ** and *** denote statistical significance at 10%, 5% and 1% respectively.

a. Lagrange multiplier ARCH test on standardized residual. The P-Values are displayed as (.).The P-Values for the linear AR(1) model are displayed as [.].

b. Ljung-Box (1978) tests for standardized residuals and squared standardized residuals with 12 lags. The P-Values are displayed as (.). The P-Values for the linear AR(1) model are displayed as [.].

Table 3. Estimation results of the MS-EGARCH(1,1) with the TFP.

	Oman	Bahrain	Kuwait	Dubai	Morocco	Egypt	Turkey	Jordan
μ_0	-0.546	-0.345	-0.494	-1.201	-0.197	-0.813	-0.665	-0.205
	(0.104***)	(0.117***)	(0.172**)	(0.277***)	(0.177)	(0.174***)	(0.259**)	(0.144)
μ_1	0.123	0.033	0.086	0.052	0.077	0.186	0.221	0.106
	(0.038***)	(0.021*)	(0.038**)	(0.055)	(0.042*)	(0.051***)	(0.112**)	(0.048**)
ω_0	1.299	0.301	1.014	1.4	0.947	1.279	1.655	0.666
	(0.073***)	(0.07***)	(0.075***)	(0.082***)	(0.076***)	(0.072***)	(0.13***)	(0.069***)
ω_1	-0.722	-1.244	-0.536	-0.463	-0.006	-0.018	0.799	-1.162
	(0.046***)	(0.08***)	(0.065***)	(0.123***)	(0.185)	(0.063)	(0.067***)	(0.156***)
α_1	-1.481	-0.684	-0.959	-1.569	-0.79	-1.161	-0.616	-1.035
	(0.060***)	(0.06***)	(0.063**)	(0.067***)	(0.065***)	(0.058***)	(0.131***)	(0.058***)
α_2	-0.224	0.155	0.351	-0.695	0.468	-0.064	-0.345	-1.024
	(0.041***)	(0.042***)	(0.055***)	(0.099***)	(0.155***)	(0.051)	(0.146***)	(0.228***)
β_0	0.317	0.329	0.428	0.317	0.452	0.464	0.567	0.362
	(0.021***)	(0.049***)	(0.032***)	(0.023***)	(0.048***)	(0.028***)	(0.053***)	(0.028***)
β_1	0.185	0.21	-0.13	0.308	0.088	-0.133	0.221	0.364
	(0.026***)	(0.051***)	(0.044**)	(0.125**)	(0.132)	(0.041***)	(0.076**)	(0.188**)
δ_0	-0.198	-0.197	-0.196	-0.206	-0.175	-0.184	-0.642	-0.021
	(0.021***)	(0.033***)	(0.031***)	(0.017***)	(0.039***)	(0.026***)	(0.215**)	(0.029)
δ_1	-0.882	-0.830	0.011	-0.7	-0.076	-0.118	-0.329	-0.508
	(0.022***)	(0.075***)	(0.138)	(0.123***)	(0.039*)	(0.028***)	(0.115**)	(0.14***)
p_{00}	0.918	0.876	0.941	0.877	0.966	0.912	0.95	0.959
	(0.041***)	(0.042***)	(0.446**)	(0.271***)	(0.557*)	(0.128***)	(0.418**)	(0.478**)
p_{11}	0.975	0.965	0.975	0.969	0.983	0.97	0.971	0.979
	(0.239***)	(0.341**)	(0.441**)	(0.269***)	(0.443**)	(0.159***)	(0.295***)	(0.458**)
LogLik	-863.5	-493.27	-797.72	-1052.77	-846.59	-985.46	-1356.48	-857.5
LR	128.68***	65.94	44.34	77.92	20.08	63.14	25.94	1.34
	[0.000]	[0.000]	[0.000]	[0.000]	[0.0209]	[0.000]	[0.0021]	[0.999]
E(D)	12.19	8.06	16.94	8.13	29.41	11.36	20	-

Notes: The figures in parentheses are standard error of the estimators. * Significance of the coefficients at the 10% level. ** Idem 5% level.*** Idem 1% level. The P-Values for Davies test are displayed as [.].

Table 4. Estimation results of the MS-EGARCH(1,1) with the TVPT.

	Oman	Bahrain	Kuwait	Dubai	Morocco	Egypt	Turkey
μ_0	-0.580	-0.326	-0.498	-1.044	-0.345	-0.779	-0.813
	(0.207**)	(0.112**)	(0.154***)	(0.207***)	(0.185*)	(0.241***)	(0.094***)
μ_1	0.119	0.038	0.186	0.054	0.086	0.233	0.227
	(0.035***)	(0.021*)	(0.086**)	(0.055)	(0.043**)	(0.057***)	(0.114**)
ω_0	1.410	0.393	0.852	1.648	0.236	-2.473	0.657
	(0.078***)	(0.075***)	(0.080***)	(0.088***)	(0.15*)	(2.891)	(0.067***)
ω_1	-0.190	-1.017	-0.477	0.094	0.001	-3.538	-0.679
	(0.148)	(0.15***)	(0.079***)	(0.058*)	(0.116)	(2.491*)	(0.098***)
α_0	-1.260	-0.446	-0.817	-1.457	-0.819	-4.435	-0.657
	(0.065***)	(0.065***)	(0.067***)	(0.072***)	(0.091***)	(3.938)	(0.078***)
α_1	0.527	0.735	0.360	-0.246	-0.251	-2.735	-0.352
	(0.143***)	(0.122***)	(0.058***)	(0.06***)	(0.145**)	(3.251)	(0.164***)
β_0	-0.074	0.509	-0.115	0.007	0.514	0.552	0.618
	(0.153)	(0.145***)	(0.141)	(0.105)	(0.395)	(0.6)	(0.063***)
β_1	-0.251	0.059	-0.048	-0.019	-0.283	0.584	0.603
	(0.223)	(0.198)	(0.075)	(0.044)	(0.099**)	(0.293**)	(0.057***)
δ_0	-0.181	-0.189	-0.184	-0.186	0.32	-1.02	-0.123
	(0.032***)	(0.036***)	(0.033***)	(0.03***)	(0.095***)	(0.917)	(0.027***)
δ_1	-0.151	-0.195	-0.111	-0.053	0.191	0.188	-0.023
	(0.036***)	(0.041***)	(0.033***)	(0.043)	(0.213)	(0.217)	(0.023)
θ_0	2.577	2.197	2.804	2.128	3.783	2.311	2.902
	(0.387***)	(0.247***)	(0.413***)	(0.253***)	(0.627***)	(0.336***)	(0.29***)
λ_0	4.287	3.032	3.598	3.446	4.319	3.208	3.36
	(0.527***)	(0.217***)	(0.367***)	(0.244***)	(0.475***)	(0.29***)	(0.413***)
θ_1	-0.106	-0.225	-0.035	-0.246	-1.298	-0.027	-0.049
	(0.124)	(0.084**)	(0.132)	(0.084**)	(0.373***)	(0.114)	(0.163)
λ_1	-1.384	1.22	0.389	0.058	0.436	0.348	0.395
	(0.606**)	(0.394***)	(0.272)	(0.134)	(0.151**)	(0.094***)	(0.13***)
LogLik	-860.526	-487.791	-797.033	-1051.95	-838.624	-981.168	-1352.83
LR	5,948	10,958**	1,374	1,64	15,932***	8,584**	7,3**
Mean Contagion result	no	yes	no	no	yes	yes	yes

Note: The figures in parentheses are standard error of the estimators.
* Significance of the coefficients at the 10% level. ** Idem 5% level.*** Idem 1% level.

time-varying probabilities to govern movements across regimes. In a second step, we investigate whether a decrease (increase) in the US returns (US returns volatility) will lead to decrease the probabilities of remaining in a no-crisis regime (bull market).

Empirical results of mean and volatility contagion are presented in table 4 and table 5 respectively. For the first step, we use the likelihood ratio (LR) tests in

Table 5. Estimation results of the MS-EGARCH(1,1) with the TVPT for the contagion volatility.

	Oman	Bahrain	Kuwait	Dubai	Morocco	Egypt	Turkey
μ_0	-0.402	-0.293	-0.488	-0.179	-0.248	-0.717	-0.852
	(0.258*)	(0.109**)	(0.146***)	(0.259)	(0.157*)	(0.136***)	(0.145***)
μ_1	0.128	0.037	0.080	-0.041	0.08	0.218	0.226
	(0.033***)	(0.022*)	(0.036**)	(0.06)	(0.041**)	(0.051***)	(0.114**)
ω_0	1.139	0.255	0.869	1.038	0.695	1.692	0.512
	(0.105***)	(0.077***)	(0.064***)	(0.094***)	(0.092***)	(0.167***)	(0.071***)
ω_1	-1.642	-1.197	-0.497	-0.792	0.009	0.492	-0.855
	(0.292***)	(0.237***)	(0.112***)	(0.242***)	(0.104)	(0.147***)	(0.188***)
α_0	-1.145	-0.356	-0.819	-0.989	-1.671	-1.182	-0.606
	(0.072***)	(0.06***)	(0.056***)	(0.072***)	(0.075***)	(0.171***)	(0.081***)
α_1	-1.517	0.791	0.495	-0.781	-0.236	-0.442	-0.573
	(0.332***)	(0.136***)	(0.096***)	(0.27**)	(0.06***)	(0.147***)	(0.348*)
β_0	0.457	0.473	0.047	0.693	-0.344	-0.275	0.676
	(0.317*)	(0.286*)	(0.163***)	(0.495)	(0.075***)	(0.16*)	(0.122***)
β_1	0.758	-0.074	-0.31	0.39	-0.356	-0.498	0.605
	(0.843)	(0.262)	(0.156***)	(0.35)	(0.087***)	(0.464)	(0.081***)
δ_0	-0.225	-0.197	-0.179	-0.182	0.571	0.009	-0.124
	(0.033***)	(0.038***)	(0.033***)	(0.03***)	(0.034***)	(0.143)	(0.027**)
δ_1	-0.189	-0.198	-0.107	0.1	-0.031	0.059	-0.036
	(0.042**)	(0.07**)	(0.033***)	(0.064*)	(0.08)	(0.078)	(0.022*)
θ_0	2.360	2.087	2.852	2.113	3.271	2.373	2.762
	(0.426***)	(0.328***)	(0.483***)	(0.284***)	(0.446***)	(0.321***)	(0.478***)
λ_0	3.674	3.209	3.806	2.895	4.26	3.329	3.469
	(0.426***)	(0.206***)	(0.427***)	(0.329***)	(0.451***)	(0.313***)	(0.616***)
θ_1	-0.251	-0.278	-0.203	-0.275	0.300	-0.348	0.534
	(0.052***)	(0.048***)	(0.057***)	(0.041***)	(0.042***)	(0.104***)	(0.058***)
λ_1	-0.157	-0.688	-0.305	-0.122	0.341	-0.157	0.114
	(0.056**)	(0.287**)	(0.141**)	(0.044**)	(0.055***)	(0.04***)	(0.063*)
LogLik	-854.014	-488.825	-796.851	-1046.178	-840.606	-975.102	-1352.36
LR	18.972***	8.89**	1.738	13.184***	11.968***	20.716***	8.24**
Volatility Contagion result	yes	yes	no	yes	no	yes	no

Note: The figures in parentheses are standard error of the estimators.
* Significance of the coefficients at the 10% level. ** Idem 5% level.*** Idem 1% level.

order to compare the fixed transition probabilities model with two time-varying transition probabilities models. In the first model, the probability of a switch in regime is assumed to vary with US return. In addition, in the second model, the probability of a switch in regime is assumed to vary with US volatility. Following

Baur (2003), the unconditional US market volatility is measured using the square of daily US returns r_t^2. We test in these two cases for the null hypothesis according to which the transition probabilities are constant. As reported in Table 4, results support the rejection of the null hypothesis at a significant level of 5% for Bahrain, Morocco, Egypt and Turkey. In these cases, the LR statistic exceeds the χ^2 (2) that is equal to 5.99 and 9.21 assuming a 5% and 1% level of confidence, respectively. Hence, we can assert that there is evidence of a statistically significant response of these countries stock markets to the US stock markets return variation. In addition, the results in Table 5 indicate that the LR statistic of Oman, Bahrain, Dubai, Egypt and Turkey exceeds the χ^2 (2). These results prove that US volatility provides useful information in explaining the time variation in the transition probabilities. However, it turns out that the Kuwait stock market is not affected by the US stock market return variation and volatility. This immunity to shocks originated in the US does not exclude the possibility that the Kuwait stock market could be affected by other regional shocks explaining switches between bull and bear markets.

In addition, as with the fixed transitions probabilities, the results of selected countries in Table 4 and 5 are also consistent with the existence of two regimes since the intercept of model seems lower in the "low mean-high variance" regime than in the "high mean-low variance" regime and the intercept of the conditional variance is substantially higher in the bear market than in the bull market.

In the countries for which we have revealed a strong presumption of "contagion" using LR test, we next analyze the marginal effect of the US stocks returns and US volatility on stock markets of these countries in order to confirm the existence of a mean contagion and/or volatility contagion. Table 4 and 5 present the coefficient estimates of (θ_0, θ_1, λ_0, λ_1) which enable us to identify the direction of the impact on the various MENA stock markets, according to the criteria discussed above.

For countries where a significant impact of US returns is verified using LR test (Table 4), estimates $\hat{\lambda}_1$ have a plausible sign and they are statistically significant. $\hat{\lambda}_1$ is positive and equal to 1.22, 0.436, 0.348 and 0.395 for Bahrain, Morocco, Egypt and Turkey, respectively. Given the positive sign, the fall in the US stock market return raises the probability of switching from high mean-low variance regime to the low mean- high variance regime in MENA stock markets. This result provides evidence that the shocks of US return have a negative effect on the probability of remaining in the no-crisis regime and send these MENA stock markets into bear market. We could interpret this result as the evidence of mean contagion from the US Subprime financial crisis to Bahrain, Morocco, Egypt and Turkey.

Moreover, volatility contagion can be found for Oman, Bahrain, Dubai and Egypt stock markets (Table 5). With the exception of Turkey and Morocco from countries where a significant impact of US volatility is verified by the LR test, estimates $\hat{\lambda}_1$ for all countries have a negative sign and are statistically significant. These findings provide evidence that an increase in the US stock market volatility raises the probability of switching from high mean-low variance regime to the low mean-high variance regime. That is, a negative reaction occurs in Oman, Bahrain, Dubai and Egypt stock markets due to the US stock market volatility shocks during the subprime financial crisis.

Overall, our results suggest that the US stock market return is statistically important in the prediction of low-returns, high variance regime for most MENA stock markets during the subprime financial crisis. We find that there is mean and volatility contagion. Both types of contagion lead to an increased likelihood of occurrence of crisis in these countries. This result brings to light the effect of the subprime crisis on these MENA markets sentiments. According to Goldstein (1998), the subprime crises played a “wake-up call” role for the MENA investors, essentially domestic investors whose changes in expectations are behind the switch from a good to a bad (crisis) equilibrium (Masson, 1999). By contrast, Kuwait stock market does not seem to be significantly influenced by the US stock market, which implies that this market is relatively immune to shocks originating from the US. However, evidence of bear market for Kuwait stock market could be generated by other regional or other international shocks during the global financial crisis, for example a fall in the oil price at the end of 2008. In addition, our test does not identify any switching of mean and volatility for the Jordan stock market during the subprime crisis.

V. Conclusion

This paper is an attempt to investigate whether any of the developing stock markets of MENA region have been affected by the financial “contagion” of the 2007 US subprime crisis. To this end, we have extended the Cerra and Saxena (2002) methodology using a MS-EGARCH model with time-varying transition probabilities in order to test “contagion” from the US stock market (ground-zero country) to eight MENA stock markets.

Our results highlight a significant increase in the likelihood of crisis occurrence characterized by low return and high volatility, following the US stock market fall and the US volatility rise. Our study gives evidence of mean and volatility contagion in the Bahrain and Egypt stock markets. It also reveals a mean contagion to Morocco and Turkey, while the contagion to Oman and Dubai is explained only by the US volatility (volatility contagion).

The fact that very different countries have been contaminated, as shown in our study, tends to give credence to the global characteristic of the crisis. On the one hand, among affected market in our sample, there is for example Morocco, one of the smallest markets in the MENA region, with a market capitalization equal to $9.2 billion in 2009, and only 56 listed stocks (see table 8 in appendix). We have also larger stock markets (for example: Egypt and Turkey). If we consider the stock market capitalization to GDP ratio (table 9 in appendix), which is generally considered as an indicator of over (if greater that 100) or undervaluation (if smaller than 100), we have overvalued (Bahrain) as well as undervalued markets (Egypt, Oman). Thus, we can deduce from our research the important magnitude of the current financial crisis which is affecting a large variety of markets, regardless of their characteristics (size of the market, liquidity, stage of liberalization, level of international financial integration and so on). On the other hand, our sample also includes GCC and non GCC countries. This implies that the current financial crisis is not related to the type of specialization of the countries under consideration (oil exporting countries or more diversified economies). These findings might suggest that international portfolio diversification in segmented MENA equity markets has not really been an efficient instrument of immunization against the risk of contagion.

Today, some experts are singing the praises of disconnection and celebrating the emergence of a new refocused, inward-looking mode of development. They recommend to stop or even to reverse the process of economic and financial liberalization, so as to reduce reliance on international capital investment and on trade relations (foreign outlets and supplying) and to base development on domestic resources and activities

In order to support such a policy, it would be necessary to establish a causal relationship between international commercial and financial integration and "contagion". It would be necessary to prove that the developing and emerging counties which have been spared the devastating effects of financial turmoil and contagion, because of their lack of integration into the international financial system and the low level of capital inflows. In fact, this proof remains to be shown. In one sense, our study tends to suggest the opposite, without establishing any reliable proof, due to the small number of countries in our sample. No doubt that a complete and undifferentiated withdrawal into oneself might be a good recipe for low growth, high unemployment, and losing opportunities to benefit from the global evolution. To preserve their economies from the excesses of globalization, MENA countries should rather further strengthen their domestic financial systems by enhancing prudential regulations and supervision. They should continue their efforts and progress in deepening capital markets so as to improve liquidity and in diversifying sources of financing.

No need to throw the baby out with the bathwater.

Acknowledgement

The authors are grateful to Professor Magda Kandil for providing us with many valuable comments at the ERF 17th annual conference.

Received 27 February 2011, Revised 8 November 2011, Accepted 10 November 2011

References

Abiad A. (2003), "Early Warning Systems: A Survey and a Regime-Switching Approach". *IMF Working Paper*, WP/03/32.

Alper C.E. and Yilmaz K. (2004), "Volatility and contagion: evidence from the Istanbul stock exchange", *Economic Systems*, **28**(4), pp. 353-367.

Baur D. (2003), "Testing for contagion - mean and volatility contagion". *Journal of Multinational Financial Management*, **13**(4), pp. 405-422.

Bekaert G., Harvey C. and Lundblad C. (2005), "Does financial liberalisation spur growth?". *Journal of Financial Economics*, **77**(1), pp. 3-55.

Bollerslev T. (1986), "Generalized Autoregressive Conditional Heteroskedasticity", *Journal of Econometrics*, **31**(3), pp. 307-327.

Brunetti C., Scotti C., Mariano R.S. and Tan A.H.H. (2008), "Markov switching GARCH models of currency turmoil in Southeast Asia", *Emerging Markets Review*, **9**(2), pp. 104-128.

Cai, J. (1994), "A Markov model of switching-regime ARCH", *Journal of Business & Economic Statistics* **12**(3), pp. 309-316.

Calvo G.A. (1999), "Contagion in emerging markets: When Wall Street is a carrier". University of Maryland. *Mimeograph*.

Calvo S. and Reinhart C. (1996), "Capital flows to emerging countries: Is there evidence of contagion effects?". In Calvo G., Goldestein M. and Hochreiter E. (ed.), *Private capital flows to emerging markets,* Institute for International Economics.

Caporale G. M., Pittis N. and Spagnolo N. (2006), “Volatility transmission and financial crises”, *Journal of Economics and Finance*, **30**(3), pp.376-390.

Caramazza F., Luca R. and Ranil S. (2004), “International contagion in currency crises”. *Journal of International Money and Finance*, **23**(1), pp. 51-70.

Cerra V. and Saxena S.C. (2002), “Contagion, Monsoons, and Domestic Turmoil in Indonesia's Currency Crisis”. *Review of International Economics*, Vol. 10, pp.36-44,

Chen S.-S. (2009), “Predicting the bear stock market: Macroeconomic variables as leading indicators”, *Journal of Banking and Finance* **33**(2), pp. 211-223.

Chen S.-S. (2010), “Do higher oil prices push the stock market into bear territory?”, Energy Economics, **32**(2), pp. 490-495.

Cheng A-R, Jahan-Parvar M. R. and Rothman P. (2009), “An empirical investigation of stock market behavior in the Middle East and North Africa”. *Journal of Empirical Finance*, **17**, pp. 413-427.

Collins D. and Abrahamson M. (2006), “Measuring the cost of equity in African financial markets”. *Emerging Markets Review*, **7**, pp. 67-81.

Collins D. and Biekpe N. (2003), “Contagion: a fear for African equity markets?”. *Journal of Economics & Business*, **55**(5), pp. 405-426.

Corsetti G., Pericoli M. and Sbracia M. (2005), “Some contagion, some interdependence: More pitfalls in tests of financial”, *Journal of International Money and Finance*, **24**(8), pp. 1177-1199.

Corsetti G., Pesenti P., Roubini N. and Tille C. (1999), “Competitive devaluations: a welfare-based approach”. *NBER Working Paper* Series, 6889.

Davies R.B. (1977), “Hypothesis testing when a nuisance parameter is present only under the alternative”. *Biometrika*, **64**, pp. 247-54.

Dempster A.P., Laird N.M. and Rubin D.B. (1977), “Maximum likelihood from incomplete data via the EM algorithm”, *Journal of the Royal Statistical Society*, **39**, pp. 1-38.

Diebold F.X., Lee J.-H. and Weinbach G. (1994), “Regime Switching with Time-Varying Transition Probabilities”. In Hargreaves C. (ed.), *Nonstationary Time Series Analysis and Cointegration*. (Advanced Texts in Econometrics, C.W.J. Granger and G. Mizon, eds.), Oxford University Press. Oxford: 283-302.

Dooley M. and Hutchison M. (2009), “Transmission of the U.S. Subprime Crisis to Emerging Markets: Evidence on the Decoupling-Recoupling Hypothesis”. *Paper prepared for the JIMF/Warwick Conference*, March.

Dungey, M., Tambakis, D.N. (2005), “International financial contagion: what should we be looking for?” In Dungey, M., Tambakis, D.M. (Eds) *Identifying International Financial Contagion: Progress and Challenges*, Oxford University Press, NY.

Edwards S. (1998), “Interest rate volatility, contagion and convergence: an empirical investigation of the cases of Argentina, Chile and Mexico”, *Journal of Applied Economics,* **1**(1), pp. 55-86.

Edwards S. (1999), “How effective are controls on capital inflows? An evaluation of Chile's experience”. *Working paper*, June.

Edwards S. and Susmel R. (2001), "Volatility dependence and contagion in emerging equity markets", *Journal of Development Economics*, **66**(2), pp. 505-532.

Eichengreen B. (1999), *Toward a New International Financial Architecture*. Institute for International economics, Washington D.C.

Eichengreen B., Rose A.K. and Wyplosz C. (1996), "Contagious currency crises". *NBER Working Paper* no. 5681. Cambridge, Mass.: National Bureau of Economic Research.

Filardo A.J. (1994), "Business cycle phases and their transitional dynamics", *Journal of Business and Economic Statistics*, **12**(3), pp. 299-308.

Flavin T., Panopoulou E. and Unalmis D. (2008), "On the stability of domestic financial market linkages in the presence of time-varying volatility", Emerging Markets Review, **9**(4), pp. 280-301.

Flavin T. and Panopoulou E. (2010), Detecting shift and pure contagion in East Asian equity markets: A Unified Approach. *Pacific Economic Review*, Wiley Blackwell, vol. **15**(3), pages 401-421.

Forbes K. and Rigobon R. (2001), "Contagion in Latin America: Definition, Measurement, and Policy Implications", Mit-Sloan school of management and NBER, January 17.

Garcia R. and Perron P. (1996), "An analysis of the real interest rate under regime shifts", *Review of Economics and Statistics,* **78**, pp. 111-125.

Gerlach S. and Smets F. (1995), "Contagious Speculative Attacks", *European Journal of Political Economy,* **11**, pp. 45-63.

Glick R. and Rose A.K. (1999), "Contagion and trade: Why are currency crises regional?" *Journal of International Money and Finance*, **18**, pp. 603-17.

Goldstein, M. (1998), "The Asian financial crises: causes, cures and systemic implication" Policy Analysis in International Economics, Institute for International Economics.

Gray S.F. (1996), "Modelling the conditional distribution of interest rates as a regime switching process", *Journal of Financial Economics*, **42**, pp. 27-62.

Hail F. and Pozo S. (2008), "Currency crisis contagion and the identification of transmission channels", *International Review of Economics and Finance*, **17**(4), pp. 572-588.

Hamilton J.D. (1989), "A new approach to the economic analysis of nonstationary time series and the business cycle", *Econometrica*, vol. 57, pp. 357-384.

Hamilton, J.D. and Susmel R. (1994), "Autoregressive conditional heteroscedasticity and changes in regime", *Journal of Econometrics*, **64**, pp. 307-333.

Henry O. (2009), "Regime switching in the relationship between equity returns and short-term interest rates". *Journal of Banking and Finance*, **33**, pp. 405-414.

Horta P., Mendes C. and Vieira I. (2008), "Contagion effects of the US subprime crisis on developed countries". CEFAGE-UE *Working Paper* 2008/08.

Hufbauer G.C. and Brunel C. (2008), Maghreb regional and global integration; A dream to be fulfilled. Peterson Institute for International Economics, Washington D.C.

Ismail, M.T. and Isa, Z. (2008), "Identifying regime shifts in Malaysian stock market returns", *International Research Journal of Finance and Economics*, 15, pp. 44-57.

Ito T. and Portes R. (1998), "Dealing with Asian Financial Crises". *European Economic Perspectives*, 17, CERP, pp. 3-4.

Kamin S.B., Schindler J.W. and Samuel S.L. (2001). "The contribution of domestic and external factors to emerging market devaluation crises: An early warning systems approach". *International Finance Discussion Paper*, n° 711. Board of Governors of the Federal Reserve System.

Kaminsky G. and Reinhart C.M. (2000), "On crises, contagion and confusion". *Journal of International Economics,* 51, pp. 145-168.

Kaminsky G.L. and Reinhart C.M. (1999), "The Twin crises: The causes of Banking and Balance of Payments problems". *The American Economic Review*, **89**(3), pp. 473-500.

Khedhiri S. and Muhammad N. (2008), "Empirical analysis of the UAE stock market volatility", *International Research Journal of Finance and Economics*, **15**, pp. 24-260.

Lagoarde-segot T., Lucey B.M., (2007), "International portfolio: is there a role for the Middle east and North Africa?", *Journal of Multinational Financial Management*, **17** (5), pp. 401-410.

Lagoarde-segot T., Lucey B.M. (2009), "Shift-contagion vulnerability in the MENA stock markets", *The World Economy*, **32**(10), pp. 1478-1497.

Lahet D. (2009), "Le repositionnement des pays émergents: De la crise financière asiatique de 1997 à la crise de 2008", *Revue d'Economie Financière*, **95**, p. 275-306

Ljung, B. and Box G.E.P. (1978), "On a measure of lack of fit in time series models", *Biometrika*, **65**(2), pp. 297-303.

Marashdeh H. and Shrestha M.B. (2010), "Stock market integration in the GCC countries", *International Research Journal of Finance and Economics*, **37**, pp. 103-114.

Mariano R., Gutlehin B., Ozmucun S., Sahabbir T. and Alper C.E. (2004). "Prediction of Currency crises: Case of Turkey". *Review of Middle East Economics and Finance*, **2**(2), pp. 87-107.

Masson P. (1999), "Contagion: macroeconomic models with multiple equilibria". *Journal of International Money and Finance*, **18**(4), pp. 587-602.

Minot N., Chemingui M.A., Thomas M., Dewina R., and Orden D. (2010), *Trade liberalization and poverty in the Middle East and North Africa*. IFPRI, Washington D.C.

Mondher C. (2011), *Does capital account liberalization spur economic and financial performance? New investigation for MENA countries*. FEMISE Research Program. Final report. Downloadable at: http://www.femise.org/PDF/ci2008/FEM33-06.pdf

Neaime, S. (2002), 'Liberalisation and Financial Integration of MENA Stock Markets', Paper presented at the 9th Economic Research Forum Meeting, American University in Sharjah, United Arab Emirates.

Pericoli, M., Sbracia, M. (2003), A primer on financial contagion. *Journal of Economic Surveys*, **17**(4), 571-608.

Reside J.R.E. and Gochoco-Bautista M.S. (1999), "Contagion and the Asian currency crisis". *The Manchester School*, **67**(5), Special Issue, pp. 460-474.

Rigobon R. (2003), “On the measurement of international propagation of shocks: is the transmission stable?”. *Journal of International Economics*, **61**(2), pp. 261-283.

Smimou K. and Karabegovic H. (2010), “On the relationship between economic freedom and equity returns in the emerging markets: Evidence from the Middle East and North Africa (MENA) stock markets”, *Emerging Markets Review*, **11**(2), pp. 119-151.

Soofi A.S. (2008), “Global financial integration and the MENA countries: Evidence from equity and money markets”, *Review of Middle East Economics and Finance*, **4**(2), pp. 1-24.

Valdes R.O. (1997), “Emerging Market Contagion: Evidence and Theory”. *Central Bank of Chile Working Papers*, n° 7.

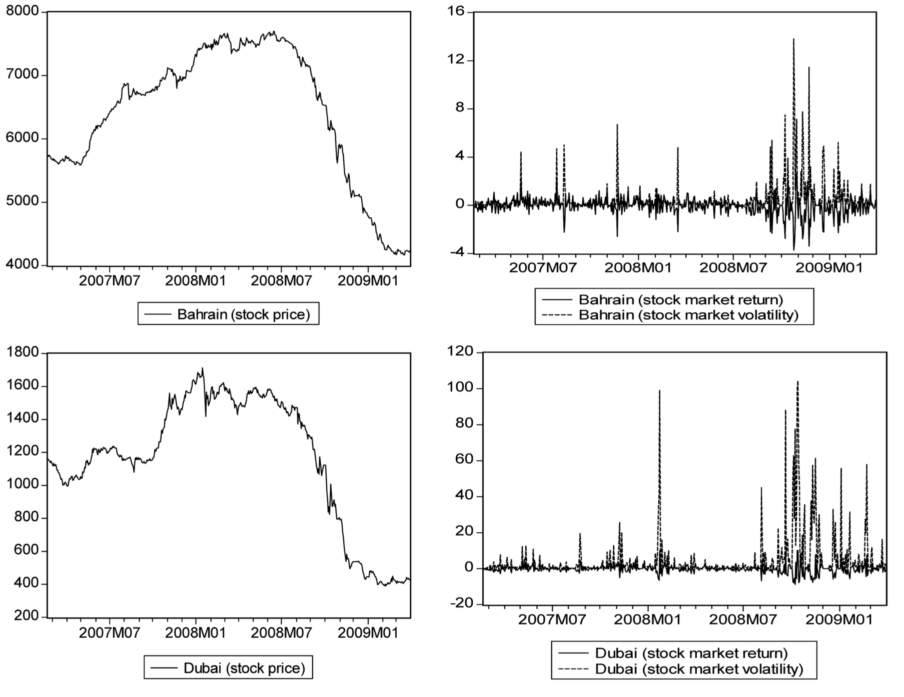
Van Rijckeghem C. and Weder B. (2001), “Source of contagion: is it finance or trade”. *Journal of International Economics,* **54**, pp. 293-308.

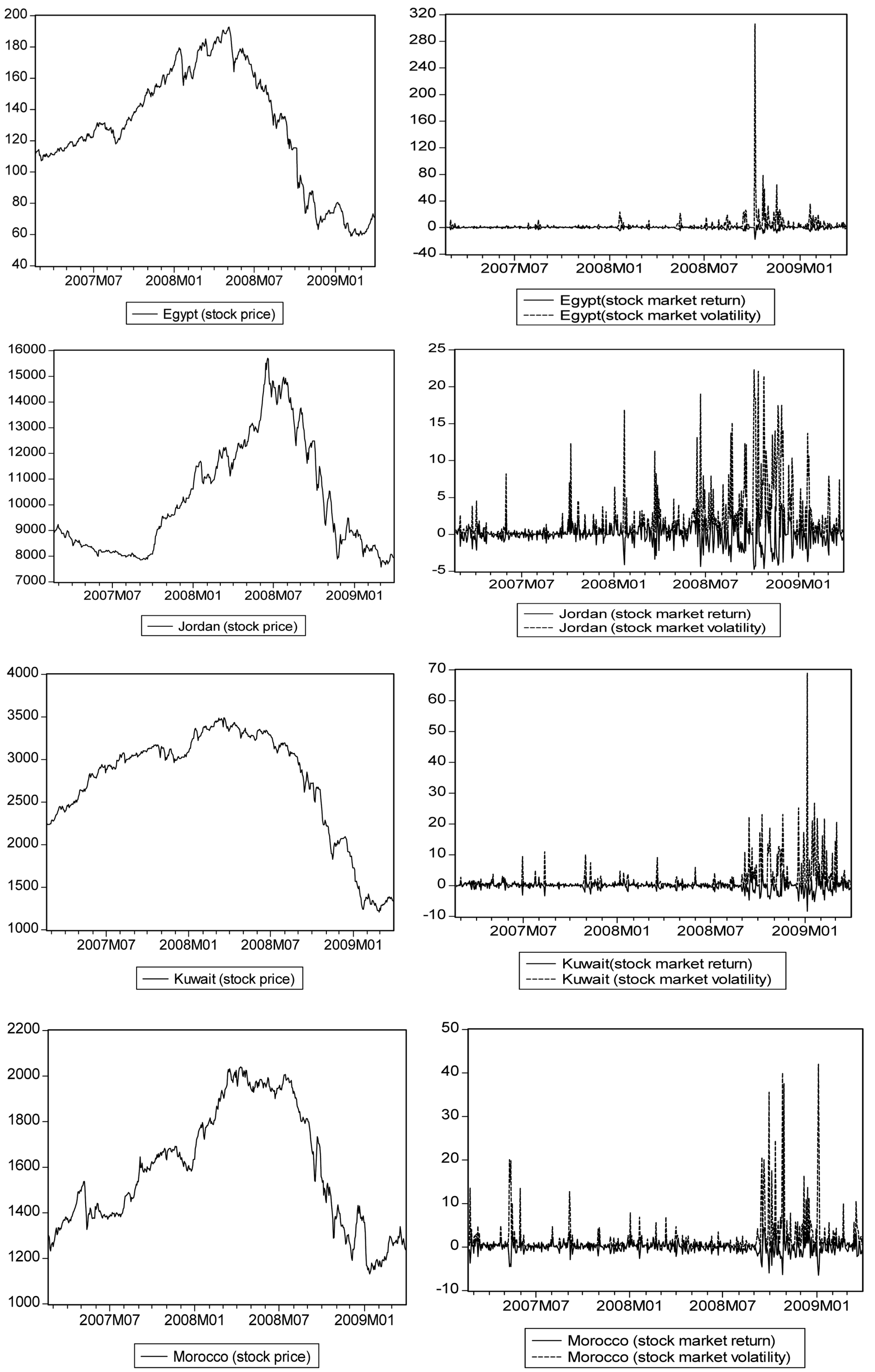
Van Rijckeghem C. and Weder B. (2003), “Spillovers through banking centers: a panel data analysis of bank flows”. *Journal of International Money and Finance*, **22**, pp. 483-509.

Yu J.-S. and Hassan M.K. (2006), “Global and regional integration of the Middle East and North Africa (MENA) stock markets”, *The Quarterly Review of Economics and Finance*, **48**(3), pp. 482-504.

Appendix

Figure 1. Daily price, returns and volatility of the MENA stock markets.




Egypt (stock price)
Egypt(stock market return)
Egypt(stock market volatility)
Jordan (stock price)
Jordan (stock market return)
Jordan (stock market volatility)
Kuwait (stock price)
Kuwait(stock market return)
Kuwait (stock market volatility)
Morocco (stock price)
Morocco (stock market return)
Morocco (stock market volatility)

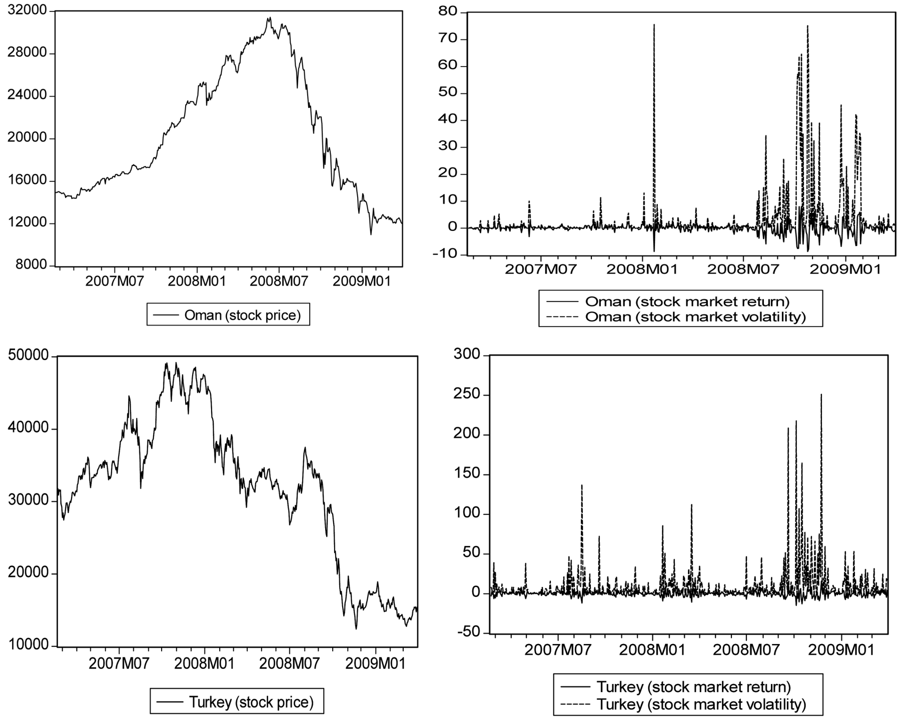
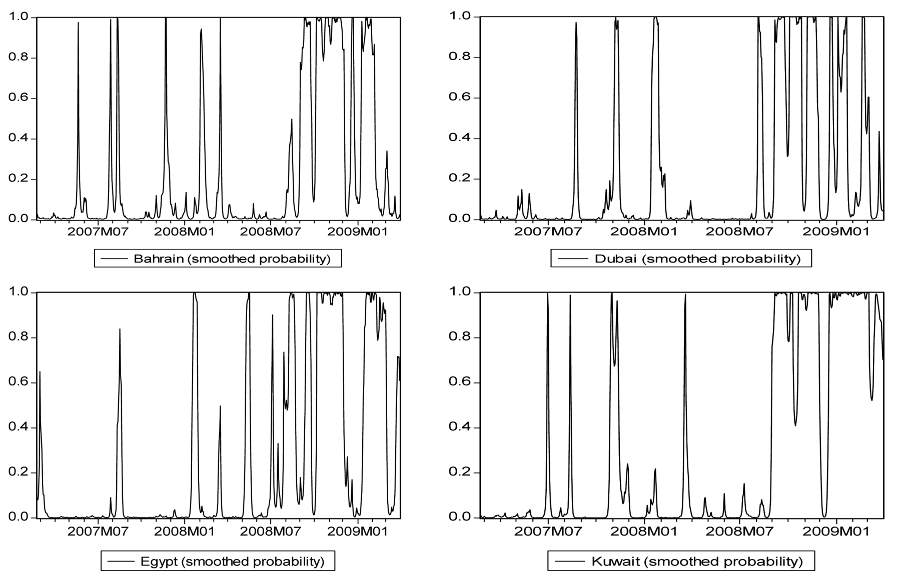


Figure 2. Smoothed probabilities of regime 0 (crisis regime).



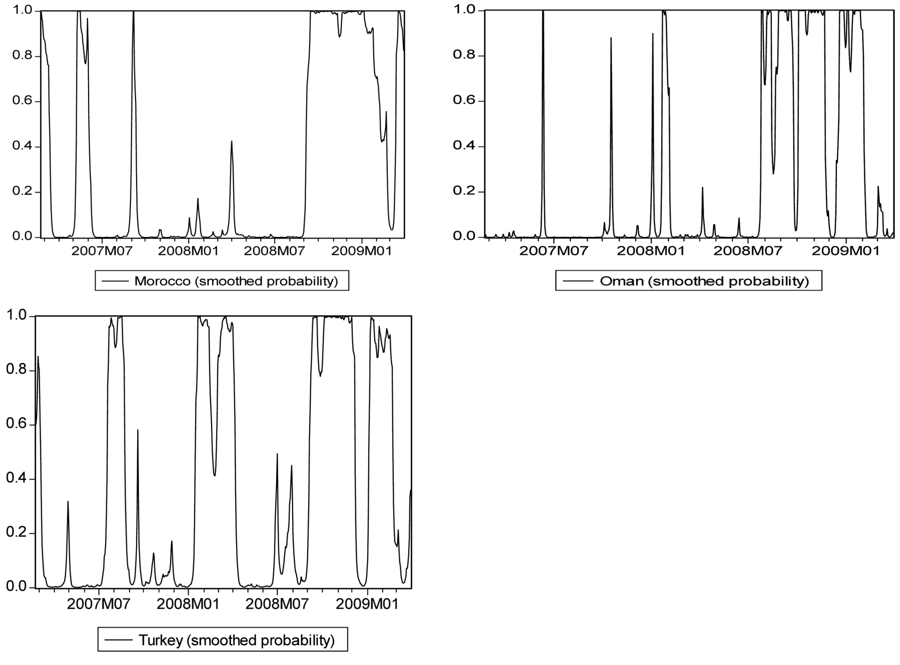


Table 6. Comparative indicators for MENA stock markets and other emerging markets (2007).

Country	Listed stocks[a]	Liquidity (%)[b]
MENA markets		
Oman	125	22.6
Bahrain	51	4
Kuwait	196	100
Dubai	55	74.8
Morocco	73	29.8
Egypt	435	47.3
Turkey	319	129.7
Jordan	245	42.3
Emerging Markets		
Argentina	111	8.87
Mexico	367	29.8
Brazil	404	57.08
Korea	1757	192.61
Singapore	762	77.6
Philippines	244	33.02
Thailand	523	66.6
Malaysia	986	57.07

Source: Smimou and Karabegovic (2010) for MENA markets. Lagoard-Segot and Lucey (2009) for Emerging markets.

a ‘Listed companies’ are the number of listed companies at the end of the year.

b ‘Liquidity’ corresponds to total value traded for the year divided by market capitalization.

Table 7. Average Daily Market Value Traded (US$ bn)

	2005	2006	2007	2008	2009	Change[(a)]
Saudi Arabia	4.415	5.611	2.728	2.094	1.300	-37.9%
Kuwait	0.402	0.244	0.558	0.534	0.150	-71.9%
Qatar	0.113	0.082	0.120	0.193	0.100	-48.1%
Oman	0.014	0.009	0.021	0.035	0.006	-82.8%
UAE (DFM & ADX)	0.572	0.489	0.614	0.595	0.120	-79.8%
Bahrain	0.003	0.005	0.004	0.008	0.001	-88.1%
Jordan	0.090	0.700	0.600	0.100	0.040	-60.0%
Egypt	0.820	0.164	0.199	0.293	0.110	-62.5%

Source: Bloomberg, Zawya & Dubai Abu Dhabi UAE Stocks and Shares Discussion Forum (a) Change from December 2008 to January 19, 2009

Table 8. Market Capitalization - Major MENA Markets (US$ bn)

	2005	2006	2007	2008	2009	Change [(a)]
Saudi Arabia	646	327	519	247	239	-3.1%
Kuwait	142	144	211	121	99	-18.7%
Qatar	87	61	93	77	61	-21.1%
Oman	13	13	23	15	14	-8.7%
UAE (DFM & ADX)	231	169	257	132	127	63.8%
Bahrain	17	21	27	20	19	-5%
Jordan	37	29	41	35	34	-1.9%
Egypt	81	95	137	57	57	0.7%

Source: Bloomberg, Zawya & Global Research & Dubai Abu Dhabi UAE Stocks and Shares Discussion Forum (a) Change from December 2008 to January 19, 2009

Table 9. Market capitalization to GDP ratio [(a)]

Country	2006	2007	2008
Bahrain	133	-	-
Egypt	87	107	53
Jordan	200	249	179
Lebanon	37	44	34
Morocco	75	101	76
Oman	45	-	-
Tunisia	14	15	16
Turkey	31	44	15

Source: Data extracted from the World Bank data base
(a) Market capitalization/GDP' is the market capitalization at the end of each year divided by GDP for the year