MODELING VOLATILITY USING UNIVARIATE AND MULTIVARIATE APPROACHES: EVIDENCE FROM MEDITERRANEAN STOCK MARKETS

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ABSTRACT

In this paper we use the univariate and multivariate GARCH models to investigate the volatility behavior of four Mediterranean stock markets (Morocco, Turkey, Spain, and France) over the period 2000-2020. Our results show strong evidence of persisting of volatility in each of these markets. We also find that both the univariate and the multivariate approaches capture well the ARCH and GARCH effects. We analyze the conditional covariances, and co-volatility spillovers between the Moroccan stock market and the three other Mediterranean stock markets. The empirical analysis will be based on the diagonal BEKK model, from which the conditional covariances will be used for studying co-volatility spillovers.

JEL: C51, C52, G15.

Key words: Conditional volatility, Multivariate GARCH, Diagonal BEKK, Volatility persistence, Volatility Spillovers.


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1. INTRODUCTION

Studying the volatility of stock returns plays an important role in portfolio management and capital budgeting. Volatility is also an essential element for the choice of risk hedging strategies and the pricing of derivatives securities. The Mediterranean stock markets constitute a new area for global investors following the suggestions of several papers that international diversification benefits can be achieved by investing regionally only (Lagoarde-
Therefore, there is need for a better understanding of their volatility behavior.

Despite the abundance studies in the financial connectedness literature, very few have focused on developing countries, particularly in the African continent. Much academic focus has been on the emerging Asian and Latin American economies. In the case of Morocco, even more scarce are the studies which have focused on the dynamics of its equity market.

Belcaid and El Ghini (2019) investigate the impact of economic policy uncertainty (EPU) in the U.S., France, Spain, Germany, the U.K., Italy and China on the long run volatility in the Moroccan stock market. The results show that, before the global financial crisis (GFC) of 2008, the link between the Moroccan stock market and the EPU is generally insignificant for the long run volatility component, namely for France and Spain. Nevertheless, during the post-crisis period the study compare results with benchmark GARCH (Generalized autoregressive conditional heteroskedasticity) models by using the Akaike information criterion (AIC) and variance ratios values. They display that almost all GARCH-MIDAS models with economic policy uncertainty perform significantly in explaining the long run volatility in the Moroccan stock market, particularly, the EPU of France, Spain and the US.

Moreover, Belcaid and El Ghini (2019) used the generalized variance decomposition to assess the transmission of volatility spillover effects among the stock markets in Morocco, the U.S., the U.K., France and Germany. Their results show relative financial connectedness between the European and Moroccan equity markets before the GFC. After that, and despite a relative increase of spillover effects coming from the U.S. equity market, the authors displayed decline in net spillover effects experienced by Morocco after the GFC.

Ahmed, A. D., & Huo, R. (2018) analyze the dynamic linkages and volatility transmission mechanisms between Chinese and African stock markets, including Morocco, in recent years while highlighting the relative importance of Chinese capital flows and investments. The study use of dynamic forecasting models including Bayesian VAR and BEKK GARCH to estimate both price and volatility behaviors of Chinese and 15 selected African stock markets. The empirical results indicate strong evidence of spillover effects in terms of both price movement and volatility behavior, implying that Chinese and African stock markets are showing signs of integration.

Moreover, using daily data spanning the period from 2002 through 2012, El Ghini and Saidi (2017) applied the Dynamic Conditional Correlation, the Constant Conditional Correlation and the BEKK specifications. They found a significant positive correlation between the Moroccan stock market and those of the U.S., the U.K. and France. Furthermore, the results provide evidence about the existence of significant spillover effects from the U.S. and European stock markets to the Moroccan one.

Similarly, based on selected GARCH specifications, Neaime (2012) investigated regional and global financial links between the Middle East and North Africa (including Morocco) stock markets and the more developed financial markets of the US, UK, and France. The results display that the transmission of crisis effects varies according to the trade channel pass through and the financial integration.

Moreover, using the EGARCH model and artificial neural networks on the stock markets of Morocco and Saudi Arabia, Lahmiri (2012) shows that trading volume improves the forecasting accuracy of this approach in Morocco. More precisely, the future volatility is over predicted during high volatile periods.

Alagidede and Panagiotidis (2009) investigate the behavior of stock returns in Africa's largest markets namely, Egypt, Kenya, Morocco, Nigeria, South Africa, Tunisia and Zimbabwe. The validity of the random walk hypothesis is examined and rejected by
employing a battery of tests. Secondly they employ smooth transition and conditional
volatility models to uncover the dynamics of the first two moments and examine weak form
efficiency. The empirical stylized facts of volatility clustering, leptokurtosis and leverage
effect are present in the African data.

Bozma & Ağirman & Ahmid (2018) study the volatility spillovers among stock market
located in Turkey and North Africa (Egypt, Tunisia and Morocco) by using VARMA-BEKK
GARCH. Results show that the Turkish stock market is not affected by the stock market
returns of any of other countries but it affects Moroccan stock market.

In parallel, our choice of the other three Mediterranean countries (France, Spain and
Turkey) is justified by their strong economic relations with Morocco. France and Spain
remain the primary European trade partners, as well as the primary creditors and foreign
investors in Morocco. In addition, Turkey and Morocco also enjoy strong economic relations.
Following the free trade agreement promulgated in 2006, bilateral trade relations between the
two countries over the period 2006-2019 almost tripled to reach US $ 2.9 billion.

In summary, our paper contributes to the existing literature in multiple dimensions. First,
McAleer (2019a) and McAleer (2019b) highlight the shortcomings of DCC and full BEKK
models, and suggest that diagonal BEKK is a more reliable model. However, as noted by
Chang et al. (2019), very few papers have adopted the diagonal BEKK model to estimate
volatility spillovers.

Our findings could contribute to improve the efficiency of asset allocation for portfolio
managers and individual investors. It is widely recognized that an accurate estimation of stock
market volatility is important for meaningful portfolio allocation and risk management (e.g.,
Chong & Miffre, 2010; Roumpis & Syriopoulos, 2014; Sadorsky, 2014).

The remainder of this paper is organized as follows. Section 2 contains the econometric
models. We present variables; including summary statistics and preliminary analysis in
section 3, while the estimation results and discuss some remarkable insights are set out in
Section 4. At the end, Section 5 highlights some concluding remarks.

2. ECONOMETRIC MODELS
2.1. Univariate GARCH-class models
Following the seminal work of Engle (1982), the most popular volatility model is the
GARCH model proposed by Bollerslev (1986). The standard GARCH (1,1) model can be
described as follows:

\[ r_t = \mu_t + \varepsilon_t = \mu_t h_t^{1/2} \eta_t ; \quad \eta_t \sim iid(0; 1) \]
\[ h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} ; \]

where, \( \mu_t \) denotes the conditional mean and \( h_t \) is the conditional variance with the
sufficient conditions \( \omega > 0, \alpha \geq 0, \beta \geq 0 \) to ensure \( h_t > 0 \).

Another popular model capable of depicting asymmetric effect is exponential GARCH
(EGARCH) proposed by Nelson (1991). The EGARCH is given by:

\[ \log(h_t) = \omega + \alpha ([\eta_{t-1}] - E[\eta_{t-1}]) + \gamma \eta_{t-1} + \beta \log(h_{t-1}) \]

As claimed by Nelson (1991), there are no restrictions on parameters in EGARCH.

2.2. Multivariate GARCH-class models
The first class of multivariate GARCH models that we study stems from the contributions of
Bollerslev, Engle, and Wooldridge (1988). We examine more particularly the following Baba-
Engle-Kraft-Kroner (BEKK, Engle and Kroner (1995)) MGARCH model:

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where \( A_{kj} \), \( B_{kj} \), and \( C \) are \( N \times N \) parameter matrices, and \( C \) is lower triangular to ensure the positive definiteness of \( H_t \). Note the BEKK model is covariance stationary if and only if the eigenvalues of \( \sum_{k=1}^{q} \sum_{j=1}^{k} A_{kj} \otimes A_{kj} + \sum_{j=1}^{p} \sum_{k=1}^{j} B_{kj} \otimes B_{kj} \) are less than one in modulus, with the notation for Kronecker products.

Due to the computational burden involved by the estimation of a full BEKK model, we restrict the number of parameters by implementing the following “diagonal BEKK” MGARCH model:

\[
H_t = CC' + A'r_{t-1}r_{t-1}'A + DE[A'r_{t-1}r_{t-1}'A | \mathcal{F}_{t-2}]D
\]

### 2.3. Data and Statistics

The variables of interest in this study are the daily returns of four Mediterranean stock markets: Morocco, France, Spain, and Turkey which are computed as first differences of the natural logarithm multiplied by 100, of the four stock indices. The starting date of the data is January 3, 2000 and series end on June 5, 2020. We have removed the data of those dates when any series has a missing value due to no trading. Thus all the data are collected for the same dates across the stock markets and there are 4385 observations for each series.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Descriptive statistics of returns.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Morocco</td>
</tr>
<tr>
<td>Mean</td>
<td>0.010137</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.351727</td>
</tr>
<tr>
<td>Skewness</td>
<td>-0.831564</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>15.98476</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>31303.58</td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
</tr>
<tr>
<td>ADF</td>
<td>-50.85320+</td>
</tr>
<tr>
<td>LB (10)</td>
<td>317.91</td>
</tr>
<tr>
<td>LB’ (10)</td>
<td>1727.5</td>
</tr>
</tbody>
</table>

+ denote significance at the 1% for all return series.

Table 1 reports summary statistics for daily returns of sample markets over the study period. Turkey had the highest average return (0.02%) and Spain realized the lowest return (-0.001%). Unconditional volatility of Mediterranean stock markets, measured by standard deviation, is generally high, and ranges from 0.34 (Morocco) to 0.8 (Turkey). The sample skewness and excess kurtosis indicate that all the stock return distributions are negatively skewed and highly leptokurtic relative to the normal distribution. This result is confirmed by the Jarque-Bera (JB) test for normality.

Results of Ljung-Box test for serial correlation of the 10th order applied to raw and squared returns reject the null hypothesis of no autocorrelation, suggesting the presence of autoregressive parameters in the return generating processes and heteroscedastic variance for all the markets.

Finally, the Augmented Dickey-Fuller (ADF) test provides evidence to support the hypothesis of stationarity for all return series at the 1% level.
Plots of daily stock market prices and returns for each country are illustrated below. The first impression is that the indices of the two European markets (France and Spain) follow a similar movement while Morocco and Turkey experienced in general a declining trend. All return series display volatility clustering and leverage effects, making ARCH models applicable.

3. RESULTS AND DISCUSSION

3.1. Univariate Approach

Table 2 shows the in-sample estimates for two univariate models discussed in Section 2. First, beginning with the standard GARCH (1,1), the value of $\alpha$ and $\beta$ are significant and $\alpha$ is interpreted as a measure of past innovation effect on volatility, while $\beta$ as the impact of past value of volatility on today's volatility. The estimates of persistence coefficients $\alpha + \beta$ are quite close to unity, thereby indicating high degrees of volatility persistence.

Second, turning to the EGARCH, coefficient $\gamma$ shows significant asymmetric effects of standardized shocks implying that there is significant relationship between the four stock market returns and there conditional volatility. The asymmetric term is positive indicating that positive shocks have greater impact on volatility more than negative shocks of the same magnitude.

The results of the diagnostic tests on the squared residuals are shown in the lower part of Table 3. In general, the values of Log(L) are very close to each other across the two univariate models, but for different returns, they have relative large differentials.

For all indices, Ljung and Box (1978)'s Q statistics cannot reject null hypothesis of no serial correlations at the 10% level. These results are also confirmed by F-statistics of Engle (1982)'s ARCH test based on the autoregression for squared standardized residuals. That is, the two univariate models can well capture ARCH effects in the returns of these four indices.

<table>
<thead>
<tr>
<th></th>
<th>GARCH (1,1)</th>
<th>EGARCH (1,1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Masi Ibx 35 BIST 100 CAC 40</td>
<td>Masi Ibx 35 BIST 100 CAC 40</td>
</tr>
<tr>
<td>$\omega$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.009617**</td>
<td>0.007284**</td>
<td>0.012219**</td>
</tr>
<tr>
<td>(7.581077)</td>
<td>(7.986990)</td>
<td>(7.196699)</td>
</tr>
<tr>
<td>$\alpha$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.275644**</td>
<td>0.122123**</td>
<td>0.094710**</td>
</tr>
<tr>
<td>(9.593256)</td>
<td>(20.96512)</td>
<td>(14.37329)</td>
</tr>
<tr>
<td>$\beta$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.673109**</td>
<td>0.864585**</td>
<td>0.889129**</td>
</tr>
<tr>
<td>(25.72078)</td>
<td>(17.39294)</td>
<td>(16.04281)</td>
</tr>
</tbody>
</table>
ARCH(10) and ARCH (20) are the non-homoscedasticity statistics of orders 10 and 20, respectively. p
values of the statistics are reported in square brackets.

<table>
<thead>
<tr>
<th>Returns</th>
<th>GARCH</th>
<th>EGARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log-moment</td>
<td>Second moment</td>
<td>Log-moment</td>
</tr>
<tr>
<td>Masi</td>
<td>0.948753</td>
<td>-0.0228468</td>
</tr>
<tr>
<td>Ibex 35</td>
<td>0.986708</td>
<td>-0.0058114</td>
</tr>
<tr>
<td>BIST 100</td>
<td>0.983839</td>
<td>-0.007076</td>
</tr>
<tr>
<td>CAC 40</td>
<td>0.984188</td>
<td>-0.0069219</td>
</tr>
</tbody>
</table>

The sufficient condition for the existence of second moment for GARCH is $\alpha + \beta < 1$ (Ling and McAleer, 2003). Table 3 shows that the second moment condition for this model is less than one for all returns, suggesting the existence of the second moment. In Table 3, we can find that the value of $|\beta|$ in EGARCH for each return series is less than one, supporting the existence of the second moment (McAleer et al., 2007).

Lee and Hansen (1994) derive the log–moment condition of GARCH(1,1) which is $E(\log(\alpha+\beta)) < 0$.

Table 3 also shows the log–moment condition for consistency and asymptotic normality of the QMLE for GARCH. We can find that log–moment condition is satisfied for all return series. The absolute values of estimates of $\beta$ in EGARCH are less than one, also satisfying the log–moment condition (McAleer et al., 2007; Shephard, 1996).

### 3.2. Multivariate Approach

<table>
<thead>
<tr>
<th>Diagonal Bekk</th>
<th>Mor_Tr</th>
<th>Mor_Fr</th>
<th>Mor_Sp</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_1$</td>
<td>0.010111</td>
<td>0.169584***</td>
<td>0.000816</td>
</tr>
<tr>
<td></td>
<td>(0.687286)</td>
<td>(12.86546)</td>
<td>(0.053422)</td>
</tr>
<tr>
<td>$\mu_2$</td>
<td>0.171268***</td>
<td>-0.031883**</td>
<td>0.176234***</td>
</tr>
<tr>
<td></td>
<td>(12.43570)</td>
<td>(-2.034950)</td>
<td>(13.54842)</td>
</tr>
<tr>
<td>$\omega_{11}$</td>
<td>0.008762***</td>
<td>0.004780***</td>
<td>0.005344***</td>
</tr>
<tr>
<td></td>
<td>(7.573298)</td>
<td>(12.01179)</td>
<td>(7.371984)</td>
</tr>
<tr>
<td>$\omega_{22}$</td>
<td>0.005161***</td>
<td>0.004835***</td>
<td>0.004847***</td>
</tr>
<tr>
<td></td>
<td>(12.59493)</td>
<td>(8.292424)</td>
<td>(12.18142)</td>
</tr>
<tr>
<td>$\alpha_1$</td>
<td>0.244388***</td>
<td>0.345754***</td>
<td>0.297618***</td>
</tr>
<tr>
<td></td>
<td>(30.74651)</td>
<td>(36.28899)</td>
<td>(40.23809)</td>
</tr>
</tbody>
</table>
Modeling Volatility Using Univariate and Multivariate Approaches: Evidence from Mediterranean Stock Markets

<table>
<thead>
<tr>
<th>( \alpha_{22} )</th>
<th>0.367013***</th>
<th>0.283965***</th>
<th>0.347651***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(35.75805)</td>
<td>(34.80285)</td>
<td>(36.25970)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \beta_{11} )</th>
<th>0.963398***</th>
<th>0.916512***</th>
<th>0.950017***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(425.0665)</td>
<td>(219.3962)</td>
<td>(335.6889)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \beta_{22} )</th>
<th>0.907096***</th>
<th>0.953053***</th>
<th>0.915639***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(206.8584)</td>
<td>(356.2010)</td>
<td>(217.3916)</td>
</tr>
</tbody>
</table>

Covariance stationary condition

<table>
<thead>
<tr>
<th>Log(L)</th>
<th>-5620.341</th>
<th>-4255.095</th>
<th>-4444.865</th>
</tr>
</thead>
</table>

QM(10) | 16.767    | 12.147    | 9.1977    |
|       | [0.080]   | [0.275]   | [0.513]   |

QM(20) | 25.534    | 16.162    | 12.741    |
|       | [0.182]   | [0.707]   | [0.888]   |

QC(10) | 10.733    | 30.648    | 19.778    |
|       | [0.379]   | [0.001]   | [0.031]   |

QC(20) | 16.824    | 34.964    | 30.021    |
|       | [0.664]   | [0.020]   | [0.070]   |

ARCHM(10) | 0.098771 | 0.009274  | 0.000659  |
|          | [0.9213] | [0.9926]  | [0.9995]  |

ARCHM(20) | -0.438991 | -0.451041 | -0.582785 |
|          | [0.6607] | [0.6520]  | [0.5601]  |

ARCHC(10) | -0.587995 | 1.158746  | 0.132255  |
|          | [0.5566] | [0.2466]  | [0.8948]  |

ARCHC(20) | 0.407015 | 0.408901  | -0.320966 |
|          | [0.6840] | [0.6826]  | [0.7483]  |

Notes: the numbers in parentheses are z-statistics of the parameter estimates and t-statistics for the others estimates. Log(L) is the logarithm maximum likelihood function value. QM(i) and QC(i) are the Ljung and Box (1978) Q-statistic of order i computed on the squared standardized residuals for returns of moroccan stock market and another stock market, respectively. ARCHM(i) and ARCHC(i) are the nonheteroscedasticity statistics of order i for standardized residuals of moroccan stock market and another country, respectively. p-Values of the statistics are reported in square brackets. The covariance stationary condition is the eigenvalue of the matrix \( A \otimes A + B \otimes B \) (\( \alpha_{ii}^2 + \beta_{ii}^2 \) for diagonal specifications) are smaller than 1. * Denotes significance at the 10% level. ** Denotes significance at the 5% level. *** Denotes significance at the 1% level.

Table 4 reports the estimates of diagonal BEKK model and results of the diagnostic tests. The estimates of \( \alpha_{ii} \) and \( \beta_{ii} \) are significant for three pairs of series; this indicates that the four stock market have strong ARCH and GARCH effects. The eigenvalues of the matrix \( A \otimes A + B \otimes B \) (\( \alpha_{ii}^2 + \beta_{ii}^2 \) for diagonal specification) are smaller than 1 implying stationarity of the covariance process and strong degrees of volatility persistence. The Ljung and Box (1978)'s Q statistics cannot reject null hypothesis of no serial correlations at the 10% level. These results are also confirmed by F-statistics of Engle (1982)'s ARCH test based on the autoregression for squared standardized residuals. That is, the model can well capture ARCH and GARCH effects in the returns.

3.3. Volatility Spillovers

As highlighted by Chang et al. (2018a) and Chang et al. (2019), the diagonal BEKK model can only be used to test for partial covolatility effects. The full BEKK model is required to report the other two notions of spillover, namely, the full volatility and covolatility spillovers. Since we have chosen to use partial BEKK model, on account of its statistical rigor, we will only report partial covolatility spillovers.
Conditional variance-covariance equations effectively capture the volatility and cross volatility among the four stock markets because most coefficients are statistically significant. Specifically, conditional variances-covariances implied by the Diagonal BEKK Specification are presented below.

\[
\begin{align*}
\begin{array}{l}
h_{\text{Mor}} &= 0.00477989121906 + 0.11954616986 \times \text{RESID}^2_{\text{Mor}} - 0.839994150086 \times h_{\text{Mor}}(-1) \\
h_{\text{Fr}} &= 0.00485723269992 + 0.0806363042743 \times \text{RESID}^2_{\text{Fr}} + 0.908310554189 \times h_{\text{Fr}}(-1) \\
h_{\text{Mor,Fr}} &= 0.0981822862214 \times \text{RESID}^2_{\text{Mor}} + 0.873484717657 \times h_{\text{Mor,Fr}}(-1) \\
h_{\text{Mor2}} &= 0.00513230186642 + 0.134176869246 \times \text{RESID}^2_{\text{Mor}} + 0.823522820325 \times h_{\text{Mor2}}(-1) \\
h_{\text{Fr}} &= 0.00874874843906 + 0.0598838010852 \times \text{RESID}^2_{\text{Fr}} + 0.928019475165 \times h_{\text{Fr}}(-1) \\
h_{\text{Mor,Tr}} &= 0.0896382783646 \times \text{RESID}^2_{\text{Mor}} + 0.874211196168 \times h_{\text{Mor,Tr}}(-1) \\
h_{\text{Mor,Sp}} &= 0.00534410595997 + 0.0885763734189 \times \text{RESID}^2_{\text{Mor}} + 0.90253313718 \times h_{\text{Mor}}(-1) \\
h_{\text{Sp}} &= 0.00484673450403 + 0.120861500474 \times \text{RESID}^2_{\text{Sp}} + 0.838394637945 \times h_{\text{Sp}}(-1) \\
h_{\text{Mor,Sp}} &= 0.103467257613 \times \text{RESID}^2_{\text{Mor}} + 0.869872946343 \times h_{\text{Mor,Sp}}(-1)
\end{array}
\end{align*}
\]

From these empirical results we conclude a strong evidence of GARCH effect and the presence of a weaker ARCH effect. Results show a statistically significant covariation in shocks, which depends more on its lags than on past errors. Consequently, market shocks are influenced by past information which is common to the respective markets. Own-volatility spillovers (ARCH effects) are positive and significant for all four markets. The spillover effect is higher for Morocco (0.13, 0.11, 0.08) and Spain (0.1208) than for France (0.0806) and Turkey (0.0598). These coefficients show the volatility persistence for each market in terms of its own past errors. As for cross-volatility effects, Turkey has the greatest influence on the future volatility of Morocco (0.8742) while the least influential market in the study is Spain (0.8698). The cross-volatility spillovers are higher than own-volatility spillovers in Turkey and France markets contrary to Morocco and Spain. The lagged own-volatility persistence (GARCH effects) in Morocco (0.83, 0.82, 0.90), Spain (0.83), France (0.90) and Turkey (0.92). These results suggest that all markets derive more of their volatility persistence from within the domestic.

It is an important finding here that although cross-volatility persistence is heterogeneous for four markets. Moreover, the analysis implies that the magnitude of cross volatility persistence is not directly linked to geography or economic relations between the countries. It can be due to the level of integration of the market to rest of the world.

Our results confirm, first, the results of El Ghini and Saidi (2017) showing a significant positive correlation between the Moroccan stock market and France. Furthermore, the results of this study provide evidence about the existence of significant spillover effects from the European stock markets including France and Spain to the Moroccan one. Second, Bozma & Ağırman & Ahmid (2018) find that Morocco is the only country in North Africa affected by the stock market of Turkey.

**4. CONCLUSION**

In this paper, we use two different approaches to model the volatility of four Mediterranean stock markets (Morocco, Turkey, France and Spain). The first one consist to model the volatility using a univariate approach through the standard GARCH(1,1) and the EGARCH(1,1). The EGARCH model was examined because the non-negativity constraints in the linear GARCH model are too restrictive. The GARCH model imposes the non-negative constraints on the parameters while there are no restrictions on these parameters in the EGARCH model. In the EGARCH model, the conditional variance is an asymmetric function.
The results show that the coefficient of asymmetry ($\gamma$) is significant supporting the use of EGARCH model.

The results of the univariate approach show also a high degrees of volatility persistence. The presence of this property implies that the four markets respond to an amount of information flowing into the financial market and reacts to it gradually over time. Therefore, past returns changes can be used as significant information for predicting future returns changes.

Moreover, the results of the estimation of diagonal BEKK model indicates also that the four stock market have strong ARCH and GARCH effects and the covariance process is stationary implying a strong degrees of volatility persistence.

In conditional variance-covariance equations, there exist significant and strong volatility spillover effects for all four markets. Magnitude of the estimates is not homogeneous across countries but remains within a relatively tight range. Influence of lagged covariance on future covariance is found to be positive in all estimations and is extremely high with values often greater than 83%. Hence the Diagonal BEKK Model exhibits very large GARCH and relatively low ARCH effects. Comovement across markets does not appear to be directly linked to geography or economic relations between the countries due to financial globalization and integration.

The last but not the least, the financial integration may weaken Moroccan market against external shocks. Decision makers in Morocco must now design policies not only looking at domestic estimates, but also by considering the fact that the country is now highly linked with external markets. Hence, global financial landscape has changed, and the emerging world is no exception.

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