THE VOLATILITY SPILLOVERS BETWEEN TURKEY AND NORTH AFRICA (ETM) STOCK MARKETS: VARMA-BEKK GARCH MODEL

Dr. Öğr. Üyesi Ensar AĞIRMAN[1]
Atatürk Üniversitesi İktisadi ve İdari Bilimler Fakültesi

Araş. Gör. Gürkan BOZMA
Üniversitesi İktisadi ve İdari Bilimler Fakültesi

Alma Brook AHMİD
Atatürk Üniversitesi İktisadi ve İdari Bilimler Fakültesi

Abstract

These days one of the most important researches is the financial integration of international markets, also around the world because of the development of financial markets the emerging markets receiving more interest. This paper exam the volatility spillovers among stock market return by using VARMA-BEKK GARCH. The volatility spillovers index collected from the series of the asset returns over a period of time from 2010 until 2017 with daily data. Our method is going to applied in the stock markets located in Turkey and North Africa (Egypt, Tunisia and Morocco) moreover in North Africa there is no other stock markets except these. Because of the financial relationship between these countries Turkey and North Africa countrıes were chosen, last but not least (emerging markets in developing countries) located in the close area and there is not any paper like this also to fill the gap in the research. Our aims to understand better the movement of the volatility and volatility pass through stock market returns which were observed. Moreover, we compared diversification of portfolio between stock markets for hedging strategies and optimal hedge ratio.

JEL Classification: C18**,** C32, C51, G15, F30, F65.

Keywords: Stock Markets, Volatility Spillovers, VARMA-BEKK GARCH Model, Turkey and North Africa (ETM).

1. Introduction

These days the world are financially more connected to each other than ever before especially after the financial crisis 2008, moreover any changes happens in any country likely to has effect on the others especially the one located in the same area, also relevant news and financial or political decisions of one country might have significant impacts on the others.

One of the most important study is the volatility spillovers between countries. Diebold and Yilmaz [2012] by using vector auto-regressions (VAR) proposing measuring of daily volatility spillovers across U.S. stock, bond, foreign exchange and commodities markets between 1999 until 2010. The method were extended in Diebold and Yilmaz [2009).

[1] Corresponding Author: ensaragirman@atauni.edu.tr

In this paper we are going to follow Diebold and Yilmaz [2009] and Diebold and Yilmaz [2012] in contrast with model, they used VAR system which estimated under either the generalized decomposition or Cholesky based on a particular definition involving daily high and low prices however in this paper the model is VARMA-BEKK GARCH using spillover indexes directly from the series of asset returns and recognize the time variance ın another area which is Turkey and North Africa.

The method was applied in stock market indexes of the four countries located near to each other (Turkey, Egypt, Tunisia and Morocco). We figure both total and directional spillovers for these market indexes in the period from 2010 until 2017 with daily data.

The relationship between these countries not just in financial side also there are other relationship especially in light of historical, culture and social it has with the people's of this region.

The volume of Turkish investment in African countries has increased and in 2015 reached about 25 billion dollars moreover the Turkey's exports to Africa 2.1 billion dollars to 13.3 billion in 2012. In total, Turkish exports include materials such as iron, steel, mineral fuels, and so on. Turkish companies have significant contributions to the establishment of formal, social and economic in Africa.

On the other hand Turkey's imports from Africa have moved from 3.3 billion dollars in 2003 to 9.6 billion dollars in 2012 and the imports included many materials such as pearls and cocoa. The volume of trade between the two sides in 2013 reached about 23.4 billion dollars, and it is about 25 billion dollars in 2015. That show there is a big relationship between Turkey and African countries in general and North African countries in particular. The results which were founded interesting, the spillovers is very observable over time, such as between the Egyptian and Turkish stock markets in mid-2010 which were affected by the Arabic Spring.

Our paper is divided in to five sections: First section is the introduction. The second is the main literature Summary. The third one is Data and Methodology. The fourth is Results and Discussion. The fifth is conclusion.

2. Literature Summary

Many studies and empirical studies were done to examine if financial markets influence each other. Baumöhl and Lyocsa (2014) 32 worldwide emerging stock market in period from 2000 to 2012 to examine the relationship between time-varying correlations and conditional volatility the result was positive relations and significant in most countries and asymmetry in volatility is not a common phenomenon also the benefits of diversification decline in the period of

higher volatility. By using GARCH model and the period from 1992 to 2001 Alper and Yilmaz (2004) examine the stock return volatility spillover from EMs and financial centers to Turkish stock market (ISE) and there is clear evidence of the volatility especially in the FAC to ISE. Allen, Amram, and McAleer (2013) examin the volitiaty spilover from the stock martket of China to other stock markets by using (ARMA), (GARCH) and (VARMA GARCH) each model applied to calculate the conditinal valotility between the stock market of China and its neighbrous from the period of 1991 to 2011 the evedince show there is volatility spilover in pre-GFC and in GFC. by using an asymmetric GARCH model and (DCC) with a little changes they estimate non-parametrically which was much higher forecasting performance than the standard DCC model to examin the volatility and correlation structure of electricity prices in (EEX) index Bauwens et al. (2013). Kang, Cho and Yoon (2009) examines sudden changes in volatility and re-examined the persistence of volatility in Japanese and Korean stock markets in the period 1986-2008 they found that global financial and political events cause the sudden changes in volatility. Sadorsky (2012) examins the volatility spillovers between oil prices and the stock prices of clean energy companies and technology companies. The finding was the stock prices of clean energy companies correlate more highly with technology stock prices than with oil prices. Li and Giles (2015) this paper examines the volatility spillover between stock markets across US, Japan and six developing Asian countries (China, India, Indonesia, Malaysia, the Philippines and Thailand) in the period from January 1, 1993 to December 31, 2012. The result shows significant unidirectional shock and volatility spillovers from the U.S and it was stronger in (AFC) moreover the relationship beyween japan stock markets and asian was apparent. Yavas and Resayat (2016) examine country equity exchange traded Funds (ETF) returns and volatility spillovers in emerging stock markets, Europe and USA they found significant co-movement of returns among all samples however it is good opportunities for diversification.

3. Data and Methodology

Old generation studies, used univariate model, such as Engle (1982) (estimates the variance of the UK inflation) and Bollerslev (1986) introduced autoregressive conditional heteroskedastic (ARCH) volatility model constant in one-period. By using similar model generalized autoregressive conditionally heteroskedastic (GARCH) applied by Nelson (1991), Glosten, Jagannathan, and Runkle (1993), moreover fractionally integrated generalized autoregressive conditionally heteroskedastic (FIGARCH) applied by Baillie, Bollerslev, and Mikkelsen (1996). Recent generation studies used (MGRACH) multivariate models for instance Bollerslev, Engle, and Wooldridge (1988) is estimate for returns, bills and stock

market moreover Bollerslev's (1990) introduced the similar model however extended of seemingly unrelated regression (SUR). Referring to representation as the BEKK GARCH model applied by Engle and Kroner (1995). As new class of multivariate model Dynamic conditional correlation models DCC GARCH was proposed by Engle's (2002). The varying-correlation (MGARCH) model was proposed by Tse and Tsui's (2002). Ling and McAleer's (2003) investigates the asymptotic theory for (ARMA GARCH). Bauwens et. al (2006) this paper which model the most appropriate in multivariate ARCH-type modelling (BEKK GARCH) models are flexible however requires some parameters, for example at least four elements and very restrictive for the cross-dynamic. Multivariate volatility forecasting model which is an extension of the model (DCC) proposed by Boudt et al. (2013), The DCC and cDCC estimators were compared by Aielli's (2013). This paper exams the volatility spillovers among stock market returns in (Turkey, Egypt, Morroco and Tunisia), are introduced into the mean equation outlined below. In the mean equation, the VAR (1) - BEKK GARCH (1,1) method developed by Engle and Kroner (1995) was used for the returns of these four variables. The mean equation used in this model is as in equation (1):

$$\begin{aligned} Rt_{t+1} &= \mu + \Phi Rt_t + \varepsilon_{t+1} \\ \varepsilon_{t+1} &= H_{t+1}^{1/2}\eta_{t+1}, \end{aligned} \tag{1}$$

where $Rt_{t+1} = \left[Rt_{t+1}^{Turkey} \;\; Rt_{t+1}^{Egyht} \;\; Rt_{t+1}^{Morroco} \;\; Rt_{t+1}^{Tunisia} \right]'$ shows the returns on four variables[2] and Φ represents the estimated parameters of the lagged variables in the Rt_{t+1} mean equations by a 4x4 matrix $\Phi = \begin{pmatrix} \Phi_{11} & \Phi_{12} & \Phi_{13} & \Phi_{14} \\ \Phi_{21} & \Phi_{22} & \Phi_{23} & \Phi_{24} \\ \Phi_{31} & \Phi_{32} & \Phi_{33} & \Phi_{34} \\ \Phi_{14} & \Phi_{24} & \Phi_{34} & \Phi_{44} \end{pmatrix}$. While $\mu = [\mu_1 ... \mu_4]'$ shows a vector of constant coefficients in the mean equation, $\eta_{t+1} = \left[\eta_{t+1}^{Turkey} \;\; \eta_{t+1}^{Egypt} \;\; \eta_{t+1}^{Morroco} \;\; \eta_{t+1}^{Tunisia} \right]'$ is a vector of independently and identically distributed random noises corresponding to each return variable in the mean equation. H matrix is defined below.

The conditional variances of the above equation are estimated using VAR (1) - BEKK GARCH (1, 1). The algebraic presentation of VAR (1) - BEKK GARCH (1, 1) is given in the following equation (2):

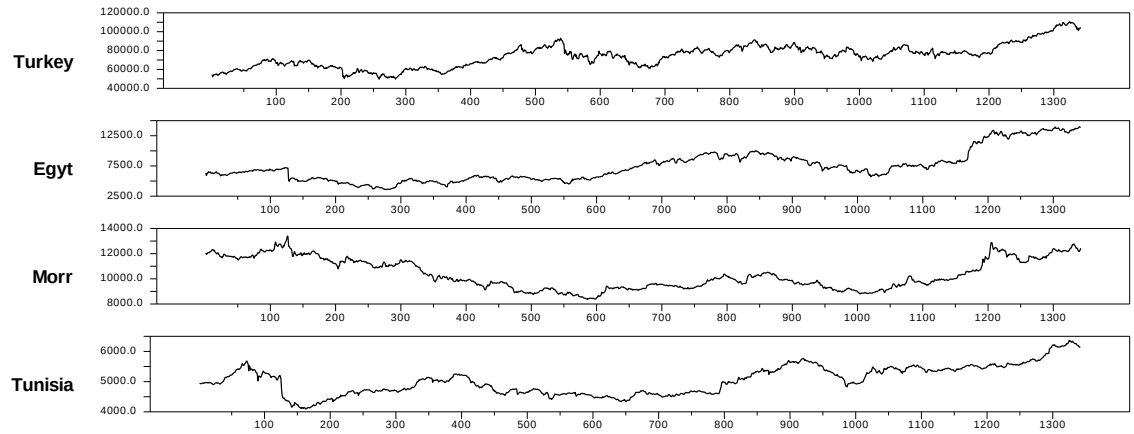
$$H_{t+1} = CC' + A\varepsilon_t\varepsilon_t'A' + BH_tB' \tag{2}$$

[2] Each stock markets's return is computed as $Rt_{i,t+1} = 100*\ln\left(\frac{P_{i,t+1}}{P_{i,t}}\right)$ where P represents the index of stock markets.

Where H is 4x4 matrix representing the conditional variance-covariance matrix, C is 4x4 upper triangular constant coefficient matrix, and A and B is each 4x4 matrix of parameters. The matrices A and B show the estimators expressing the impacts of short-term shocks and long-run volatilities, respectively.

The estimation of the VAR (1) - BEKK GARCH (1, 1) model is performed by the quasi-maximum likelihood (QML) method, assuming the conditional distribution of a joint Gaussian log-likelihood function for *t* number of observations and four variables. We used daily data for the period 2010: 05-2017:10 to examine the volatility between the stock markets obtained from www.investing.com. Graph 1 shows condition of series during the period.

Graph 1. Time-varying of Stock markets



In Graph 1, after 2015, Turkey, Egypt, Morocco and Tunisia shows a common trend in the stock market. In particular, in the middle of 2014 there is an increase in 4 stock markets. This shows intuitively that there is a close relationship between the stock markets. In Table 1, some descriptive statistics of stock return series are given.

Table 1. Descriptive Statistics

Statistics	**Turkey**	**Egypt**	**Morocco**	**Tunisia**
Mean	0.048	0.058	0.002	0.016
Std. Dev.	1.668	1.082	0.710	0.616
Skewness	-0.961	-3.514	0.287	-1.828
Kurtosis	6.244	59.634	7.153	21.320
Jarque-Bera	2385.610	201470.473	2877.811	26145.697
	(0.000)	(0.000)	(0.000)	(0.000)
LB-Q (6)	12.420	25.557	61.511	68.061
	(0.053)	(0.000)	(0.000)	(0.000)
LM-Arch (6)	3.786	0.247	10.049	33.760
	(0.000)	(0.960)	(0.000)	(0.000)
Correlation				
Turkey	1.000			
Egypt	0.201	1.000		
Morocco	0.038	0.165	1.000	
Tunisia	0.010	0.075	0.396	1.000

Note: Parenthesis show the value of probability.

In Table 1, in the 4 stock markets Egypt has the highest average return Egyptian stock market is followed by the Turkish and Tunisian stock markets. When the standard deviations on the stock market are examined, Turkey fluctuates more than the other stock markets. When the period between 2010 and 2017 was examined, both internal and external events affected the stock market in Turkey. Except the stock market in Morocco the Skewness coefficient is negative. This situation shows that Turkey, Egypt and Tunisia stock markets expected return is negatively more than positively. Skewness and kurtosis coefficients indicate that the series are not normally distributed. The Jarque-Bera statistic confirms this. Whether the series contain autocorrelation and ARCH effects were examined by Q and ARCH tests. the finding of Q and ARCH show that series have autocorrelation and ARCH effects These results show that the relationships between the series can be estimated with the MGARCH model.

4. Results and Discussion

The volatility between Turkey and North Africa (ETM) stocks market are estimated in table 2 with the VAR-GARCH BEKK model.

Table 2. Results of VAR- GARCH BEKK Model

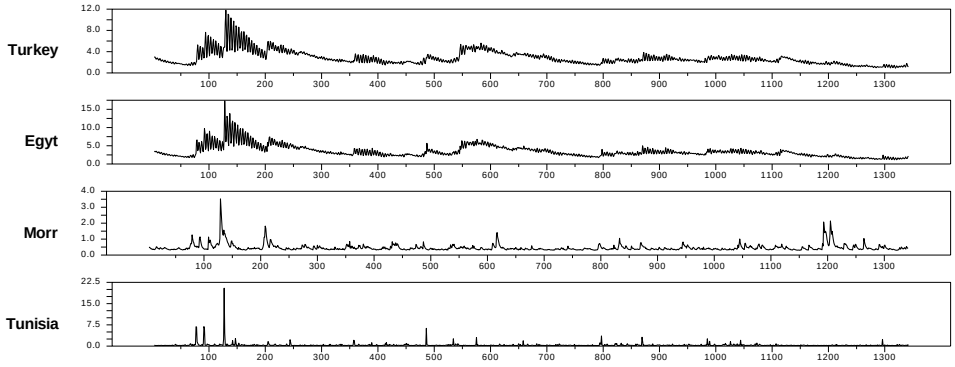
Estimate	**Turkey**	**Egypt**	**Morocco**	**Tunisia**
Conditional mean equation				
Constant (μ)	0.107*** (2.415)	0.065 (1.402)	-0.006 (-0.337)	0.038*** (2.596)
λ_{i1}	-0.037 (-1.399)	0.081*** (2.826)	0.023** (2.216)	0.016* (1.935)
λ_{i2}	-0.022 (-0.975)	0.138*** (5.245)	-0.001 (-0.145)	0.003 (0.484)
λ_{i3}	0.058 (0.934)	0.107 (1.521)	0.179*** (6.668)	0.003 (0.149)
λ_{i4}	0.098 (1.420)	0.159** (2.118)	0.021 (0.786)	0.158*** (5.426)
Conditional variance equation				
c_{1i}	-0.002 (-0.037)			
c_{2i}	0.016 (0.236)	0.155** (2.007)		
c_{3i}	0.043 (0.578)	0.180*** (1.834)	0.203** (2.298)	
c4i	-0.000 (-0.010)	-0.328** (-2.317)	0.300* (1.850)	0.003 (0.065)
a_{1i}	0.116 (6.471)	0.122 (6.747)	0.018 (1.474)	0.026 (2.055)
a_{2i}	-0.037 (-2.400)	-0.008 (-0.469)	-0.006 (-0.586)	-0.014 (-1.142)
a_{3i}	0.082 (1.862)	0.044 (0.811)	0.294 (7.627)	0.010 (0.385)
a_{4i}	-0.090 (-1420)	0.236 (2.803)	-0.001 (-0.032)	0.659 (16.901)
b_{1i}	0.662 (43.252)	-0.699 (-36.423)	-0.001 (-0.070)	-0.006 (-0.397)

b_{2i}	0.570 (36.701)	0.869 (51.081)	0.006 (0.579)	0.016 (1.096)
b_{3i}	-0.205 (-2.360)	-0.123 (-1.538)	0.821 (23.558)	0.056 (0.647)
b_{4i}	0.116 (1.006)	0.318 (2.027)	0.263 (4.116)	-0.142 (-2.386)
Diagnostic tests				
Q(6)	6.798 [0.339]	2.756 [0.838]	2.064 [0.913]	11.906 [0.064]
Q(12)	18.593 [0.098]	5.720 [0.929]	8.289 [0.762]	24.494 [0.017]
$Q^2(6)$	8.156 [0.226]	14.276 [0.026]	13.580 [0.034]	3.517 [0.741]
$Q^2(12)$	20.902 [0.051]	18.181 [0.110]	27.121 [0.007]	5.204 [0.950]
MV Q-statistic (6)	110.455 [0.148]			
MV Q-statistic (12)	218.645 [0.090]			
MV Q^2-statistic (6)	125.261 [0.024]			
MV Q^2-statistic (12)	210.453 [0.171]			
LM test on std. residuals(6)	794.28 [0.000]			
LM test on std. residuals(12)	1410.67 [0.000]			
LM test on std. seq. residuals(6)	1035.83 [0.000]			
LM test on std. seq. residuals(12)	1267.96 [0.084]			

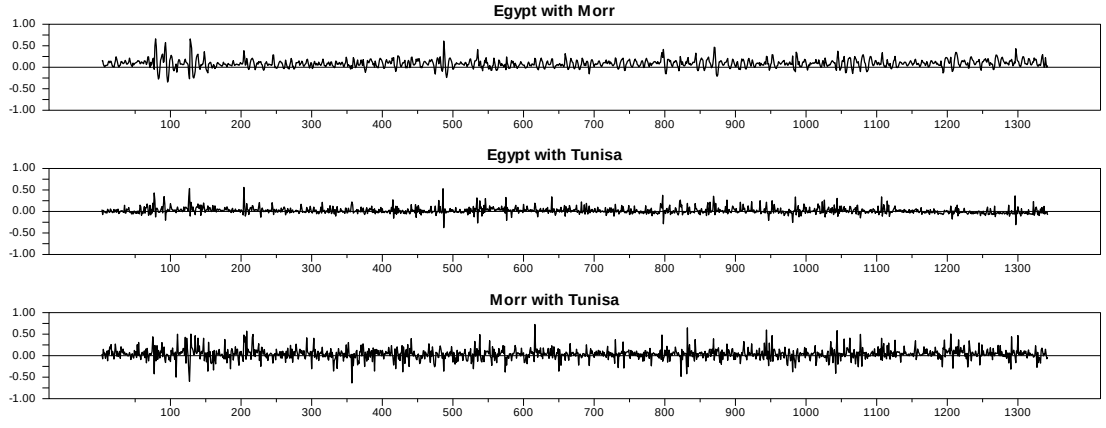
*Note: *, ** and *** are statistically significant at 10%, 5% and 1% respectively.*

Table 2 shows the parameters of mean and variance equations obtained from VAR-GARCH BEKK model. The Turkish stock market is not affected by the stock market returns of any of other countries. On the other hand, the return of the Egyptian stock market is positively affected by the return of Turkey (0.081) and Tunisia (0.159). Morocco is only country affected by the stock market of Turkey (0.023). Lastly, Turkey is affected by Tunisia (0.016) also the two other countries. This is due to the fact that the Turkish stock markets is not shallow than the other countries' stock markets.

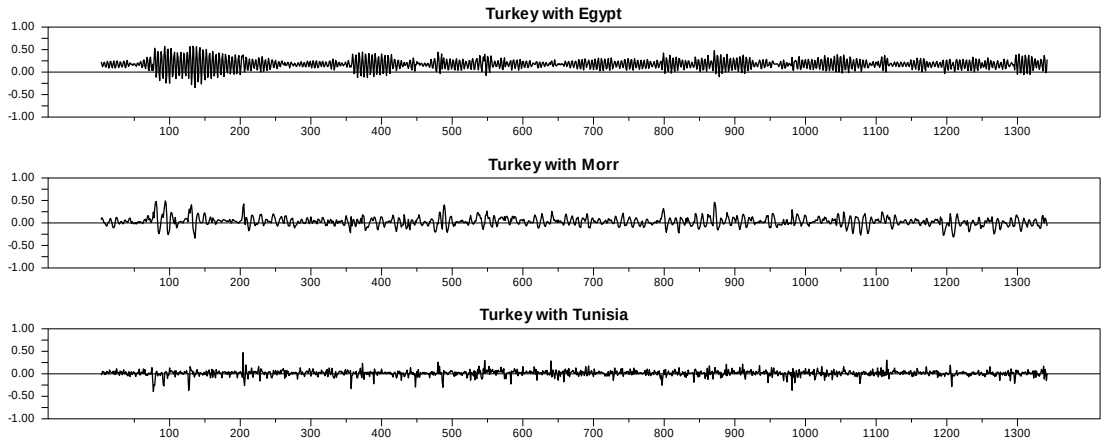
Graph 2. Conditional Variance of Stock Markets



Looking at variance equality, the conditional variance of the Turkish stock market is affected by their own short-term shocks (0.116) as well as from mutual short-term shocks of Egypt (-0.037) and Morocco (0.082). While Egypt is not affected by itself short-term shocks. However, short-term shocks (0.122) between the Turkish stock market and its stock market effected Egypt. These results show that BIST is a market that is deeper than the Egyptian stock market. The conditional variance of the Moroccan stock market is only affected by its short-term shocks (0.294). Interestingly, while short-term shocks of Tunisian stock market increases its conditional variance (0.659) while its long-term volatile reduce its conditional variance (-0.142). For Turkey, it is observed that the long-term fluctuation is more effective on the conditional variance than the short-term shocks (0.662). The same is true for Egypt (0.869) and Morocco (0.821). When looking at the diagnostic tests results of the BEKK model, standardized error terms obtained from the conditional variance equations do not have



autocorrelation and ARCH effects. Hosking's multivariate portmanteau Q-statistics also support these results. Conditional variance of stock markets discussed in Chart 2.



Graph 3. Conditional Correlation between Stock Markets

It shows that Turkey and Egypt have almost similar charts. The Egyptian and Turkish stock markets were affected by the Arabic Spring, which started in mid-2010. Graphs 3 and 4 show correlations between the conditional variances of stocks. The correlation between Turkey and Egypt pattern of volatility clustering is evident. The conditional correlation between Turkey and Egypt is shown that these two stock market is diversification each other. We can see same results for other stock markets.

5. Conclusion

In this paper we are extending the work of Diebold and Yilmaz [2009] and Diebold and Yilmaz [2012] by using different model and different area, the model was used is VARMA-BEKK GARCH to examine the multivariate relationships of volatility spillovers which were applied in Turkey and North Africa (ETM) stock markets which located in the same area by using daily data and time-variant from 2010 until 2017.

Our results showed the movements of financial returns within a framework of volatility spillovers, moreover, after 2015, Turkey, Egypt, Morocco and Tunisia shows a common trend in the stock market. In particular, in the middle of 2014 there is an increase in 4 stock markets. This shows intuitively that there is a close relationship between the stock markets.

In the period between 2010 and 2017 was examined, in the 4 stock markets Egypt has the highest average return Egyptian stock market is followed by the Turkish and Tunisian stock markets. When the standard deviations on the stock market are examined, Turkey fluctuates more than the other stock markets. Also both internal and external events affected the stock market in Turkey. Except the stock market in Morocco. This situation shows that Turkey, Egypt and Tunisia stock markets expected return is negatively more than positively.

The Turkish stock market is not affected by the stock market returns of any of other countries. On the other hand, the return of the Egyptian stock market is positively affected by the return of Turkey and Tunisia. Morocco is only country affected by the stock market of Turkey. Lastly, Turkey is affected by Tunisia also the two other countries. This is due to the fact that the Turkish stock markets is not shallow than the other countries' stock markets

The Egyptian and Turkish stock markets were affected by the Arabic Spring, which started in mid-2010 and that lead that investors due to problems such as Political and economic instability this leads investors from one country escape to another country as in Egypt and Turkey, Turkey and Egypt is shown that these two stock market is diversification each other. We can see same results for other stock markets.

References

Aielli, G.P., 2013. Dynamic conditional correlation: on properties and estimation. *Journal of Business & Economic Statistics*, *31*(3), pp.282-299.

Allen, D.E., Amram, R. and McAleer, M., 2013. Volatility spillovers from the Chinese stock market to economic neighbours. *Mathematics and Computers in Simulation*, *94*, pp.238-257.

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

Baillie, R.T., Bollerslev, T. and Mikkelsen, H.O., 1996. Fractionally integrated generalized autoregressive conditional heteroskedasticity. *Journal of econometrics*, *74*(1), pp.3-30.

Baumöhl, E., and Lyócsa, Š. 2014. Volatility and dynamic conditional correlations of worldwide emerging and frontier markets. *Economic Modelling*, *38*, pp175-183.

Bauwens, L., Laurent, S., and Rombouts, J. V. (2006). Multivariate GARCH models: a survey. Journal of applied econometrics, 21(1), pp 79-109.

Bauwens, L. and Laurent, S., 2005. A new class of multivariate skew densities, with application to generalized autoregressive conditional heteroscedasticity models. *Journal of Business & Economic Statistics*, *23*(3), pp.346-354..

Bollerslev, T., Engle, R.F. and Wooldridge, J.M., 1988. A capital asset pricing model with time-varying covariances. *Journal of political Economy*, *96*(1), pp.116-131.

Bollerslev, T., 1986. Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics*, *31*(3), pp.307-327.

Bollerslev, T., 1990. Modelling the coherence in short-run nominal exchange rates: a multivariate generalized ARCH model. *The review of economics and statistics*, pp.498-505.

Boudt, K., Danielsson, J. and Laurent, S., 2013. Robust forecasting of dynamic conditional correlation GARCH models. *International Journal of Forecasting*, *29*(2), pp.244-257.

Diebold, F. X., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal*, *119*(534), 158-171.

Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, *28*(1), 57-66.

Engle, R.F. and Kroner, K.F., 1995. Multivariate simultaneous generalized ARCH. *Econometric theory*, *11*(1), pp.122-150.

Engle, R. F. 2002. Dynamic conditional correlation. Journal of Business and Economic Statistics, 20(3), pp. 339-350.

Engle, R.F., 1982. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica: Journal of the Econometric Society*, pp.987-1007.

Glosten, L.R., Jagannathan, R. and Runkle, D.E., 1993. On the relation between the expected value and the volatility of the nominal excess return on stocks. *The journal of finance*, *48*(5), pp.1779-1801.

Kang, S.H., Cho, H.G. and Yoon, S.M., 2009. Modeling sudden volatility changes: Evidence from Japanese and Korean stock markets. Physica A: Statistical Mechanics and its Applications, 388(17), pp.3543-3550.

Ling, S. and McAleer, M., 2003. Asymptotic theory for a vector ARMA-GARCH model. *Econometric theory*, *19*(2), pp.280-310.

Li, Y. and Giles, D.E., 2015. Modelling volatility spillover effects between developed stock markets and asian emerging stock markets. *International Journal of Finance & Economics*, *20*(2), pp.155-177.

McAleer, M., Hoti, S. and Chan, F., 2009. Structure and asymptotic theory for multivariate asymmetric conditional volatility. Econometric Reviews, 28(5), pp.422-440

Nelson, D.B., 1991. Conditional heteroskedasticity in asset returns: A new approach. *Econometrica: Journal of the Econometric Society*, pp.347-370.

Sadorsky, P., 2012. Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies. Energy Economics, 34(1), pp.248-255. Vancouver

Tse, Y.K. and Tsui, A.K.C., 2002. A multivariate generalized autoregressive conditional heteroscedasticity model with time-varying correlations. *Journal of Business & Economic Statistics*, *20*(3), pp.351-362.

Yavas, B.F. and Rezayat, F., 2016. Country ETF returns and volatility spillovers in emerging stock markets, Europe and USA. *International Journal of Emerging Markets*, *11*(3), pp.419-437.