

SHOCK AND VOLATILITY SPILLOVERS BETWEEN OIL AND SOME BALKAN STOCK MARKETS

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Abstract

In this paper, we examine the volatility spillover between WTI oil and four Balkan stock markets (Romania, Bulgaria, Greece and Turkey). We also analyze the optimal weights and hedge ratios for oil-stock portfolio holdings and show how empirical results can be used to build effective hedging strategy. We used VAR-GARCH model during the period from 20 October 2000 to 08 February 2016. The findings show significant evidence of shock and volatility linkages between oil and Balkan stock markets. In particular, past oil shocks play a crucial role in explaining the dynamics of conditional return and volatility in Balkan stock markets. Moreover, the portfolio analysis suggests that adding oil to a portfolio of Balkan stocks can help to hedge effectively against stock risk exposure over time.

Keywords: transmission, VAR-GARCH, hedge ratio

JEL Classification: G12, F3, Q43

1. Introduction

Oil is a major resource and the changes in the oil prices strongly affect the stability and growth of world economy. Within the oil-economy nexus, understanding the relationship between oil and stock markets has recently received substantial attention from investors and regulators. The investigation of volatility spillovers can help investors to have proper asset pricing process and volatility forecasting between oil and stock markets. Moreover, investors would be able to anticipate fluctuations in their portfolio values due to oil and stock price shocks. From the portfolio diversification perspective, the analysis of spillover effects can be helpful in constructing the optimal weights and hedge ratios for oil-stock portfolio holdings.

Indeed, there is a link between oil and corporate stock prices through corporate cash flows and the discount rate used in stock valuation models. High oil prices lead to an increase in industrial production costs and decrease in corporate earnings (Jones and Kaul, 1996; Sadorsky, 1999, Apergis and Miller, 2009). The impact of oil shocks on stock markets differs between net oil-exporting and net oil-importing countries. In particular, the majority of net oil-importing countries are emerging markets and oil shocks put pressure on the economies of

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these markets. Concerning the net oil-importing countries, there is a considerable body of literature on oil and stock markets of large oil-importing countries such as China and Europe (Park and Ratti, 2008; Zhang and Chen, 2011; Aroui, Jouini and Nguyen, 2012; Broadstock and Filis, 2012). However, there has been no study investigating the relationship between oil and stock markets of small oil-importing countries namely Balkan countries.

The *Balkan* countries are neither major energy producers nor major consumers. Due to their geopolitical importance, these countries are rather considered as energy corridors for the oil exports of Russia and Middle East to Europe. In terms of oil consumption, the Balkan countries are relatively low-scale oil consumers. However, they heavily depend on oil imports for their energy needs. In particular, crude oil takes the first place in their imported products (Hausmann *et al.*, 2013).

In Balkan region, Turkey, Greece, Romania and Bulgaria are among the top performers of the Balkan economies and their oil consumptions are closely linked to their economic activities. As clearly noticed in Table 1, Turkey has the highest oil consumption followed by Greece, Romania, and Bulgaria. The oil consumption of these countries can be partially explained by demographic factors and economic activities. A closer inspection of Table 1 suggests that Turkey has the most populous country, followed by Romania, Greece, and Bulgaria. The similar ranking is true for the economic activities of these Balkan countries. Among them, Turkey, Greece, Romania and Bulgaria have the highest GDP. This finding implies a positive relationship among oil consumption, population and economic activities of the Balkan countries. In other words, the countries with high population and GDP are likely to consume more crude oil. Furthermore, the sampling period covers the sovereign debt crisis. Therefore, it would be interesting to see the interaction between oil market and in particular the Greek stock market.

Table 1
Energy Consumption, GDP and Population Facts for Balkan Countries

	Oil Consumption Barrels per Day (2016) ¹	GDP million Euros (2015) ²	Population 000 (2015) ²	Stock Capitalization to GDP (2012) ³
Albania	40000	9268	2.889	-
Bosnia and Herzegovina	36000	14594	3.819	13.54%
Bulgaria	94000	45287	7.197	13.63%
Croatia	84000	43847	4.213	36.96%
Greece	285000	175698	10.858	15.44%
Romania	215250	160353	19.819	10.20%
Serbia	77200	33491	7.095	17.73%
Turkey	720000	645394	74.724	31.38%
Kosova	NA	645394	1.7721	-
Macedonia	20000	90614	2.079	5.66%
Montenegro	NA	3624	622	-

¹ GlobalFirepower, 2017. Oil Consumption by Country, Available at: <<http://www.globalfirepower.com/oil-consumption-by-country>> (Accessed 28 July 2017).

² New Strategy Center, 2017. Energy and Its Impact on Development in Southeast Europe and the Black Sea Area, Research Paper.

³ World Bank, 2015. Global Stock Markets Facts.

Since Greece experienced a severe financial deterioration, the Greek stock market was the most volatile stock market amongst others. The selection of these four Balkan markets are therefore not made arbitrarily. The above-given facts accompanied with high stock market capitalization to GDP ratios show interesting nature of these Balkan markets, which needs to be studied in detail. It is also important to note that to the best of authors' knowledge, there has been yet no study examining the linkage between oil and stock returns in the Balkan region. It is upon this background that we attempt to fill this gap and investigate the volatility spillover between WTI oil and four Balkan stock markets.

The current paper has two main objectives: (1) To examine the volatility spillover between WTI oil and the four major Balkan stock markets (Romania, Bulgaria, Greece and Turkey) returns. (2) To use the estimated results to compute the optimal weights and optimal hedge ratios for stock-oil portfolio holdings in Balkan stock markets. Using daily data from 20 October 2000 to 08 February 2016, we used the VAR-GARCH approach. This model allows us to estimate the return and volatility cross-effects across oil and stock market returns. In the literature, some papers have already employed the VAR-GARCH model to investigate the volatility spillover and hedging strategies between oil and stock returns (Hammoudeh, Yuan and McAleer 2009; Arouri, Jouini and Nguyen, 2011; Arouri, Jouini and Nguyen, 2012). The findings of this paper indicate the presence of significant spillover effects between oil and Balkan stock markets in terms of shock and volatility. In particular, past oil shocks play a crucial role in explaining the conditional volatility of stock returns. This finding should be taken into account while making volatility forecasts of future stock returns. The estimates of constant conditional correlation (CCC) between oil and Balkan stock markets are low and positive. The low correlations suggest that investors can gain substantial returns by investing in Balkan countries' stock markets and oil asset. Furthermore, the portfolio analysis suggests that making oil asset as a part of a well-diversified portfolio of Balkan stocks can improve its risk adjusted performance. Thereby, the stock risk exposures can be effectively hedged using oil asset. The results have important implications for investors, policy makers and finance practitioners. Our analysis contributes to the literature in the following aspects. First, this study is the first to examine the volatility transmission between WTI oil and major Balkan stock markets. Surprisingly, there has been no study investigating the shock and volatility transmission between WTI oil and the four Balkan stock markets including Romania, Bulgaria, Greece and Turkey. This study attempts to fill this gap. Second, the current study employs a sophisticated technique of VAR-GARCH approach that has not been used to test the volatility effects for Balkan stock markets. Third, the current study analyzes optimal portfolio weights and hedge ratios for oil-stock portfolio holdings with respect to the VAR-GARCH results. To our knowledge, this study is again the first that calculates the optimal weight and hedge ratio for oil-stock portfolio holdings in the Balkan stock markets.

The remaining part of this paper is organized as follows; Section 2 provides the literature review. Section 3 describes the data and methodology. Section 4 highlights the empirical results and discussion. Section 5 summarizes the concluding remarks.

2. Literature Review

A large body of literature addresses the relationship between crude oil prices and stock market returns in the major developed countries. In a pioneering study, Hamilton (1983) examined the relationship between oil prices and US economy. The findings of the study

present considerable influence of oil prices on the US economy. In another early study, Jones and Kaul (1996) investigated the effect of oil prices on the stock markets of Canada, Japan, UK and US. They concluded that oil price fluctuations negatively affect the stock returns. Later studies also provide evidence of significant volatility spillover between oil and stock market returns in developed countries (Sadorsky, 1999; Hamilton, 2003; Apergis and Miller, 2009; Fayyad and Daly, 2011; Arouri, Jouini and Nguyen, 2011; Arouri, Jouini and Nguyen, 2012).

Most recently, Diaz, Molero and Gracia (2016) studied volatility transmission between oil and G-7 stock markets from 1970 through 2014. Their empirical results show negative response of past oil shocks to G-7 stock markets. For the opposite direction, Park and Ratti (2008) found significant and positive correlation between oil price fluctuations and 13 European stock markets over the period from 1986 to 2005. Ciner (2001) employed a non-linear causality model to examine the impact of oil shocks on US stock market and found significant relationship between oil shock and US stock market. In their paper, Malik and Ewing (2009) employed BEKK-GARCH model and used weekly returns over a period from 1992 to 2008. Their empirical findings show significant volatility spillovers between oil shocks and different sectors of US stock exchange.

In recent years, a growing body of literature has investigated the possible linkages between crude oil prices and stock markets in developing countries (Papapetrou, 2001; Malik and Hammoudeh, 2007; Bharn and Nikolovann, 2010; Masih, Peters and Mello 2011). In their comprehensive study, Basher and Sadorsky (2006) analyzed the relationship between oil prices and 21 emerging stock markets. Using conditional and unconditional approaches of international multi-factor models, they concluded that oil price fluctuations affect the stock returns of emerging stock markets.

Among the developing countries, some studies have paid attention to a particular region such as GCC (Gulf Cooperation Council) countries. In this context, Hammoudeh and Eleisa (2004) studied GCC countries and they documented a negative impact of oil prices on GCC stock markets. In another study, Hammoudeh and Choi (2006) investigated the long-run links between oil prices and stock indices of five GCC countries (Bahrain, Kuwait, Oman, Saudi Arabia and UAE). Their findings show that oil price changes have no direct effects on the GCC markets.

A number of recent papers have addressed the links between oil and Asian stock markets. These include, among others, Zhang and Chen, 2011 for China, Narayan and Narayan, 2010 for Vietnam, Zhu, Li and Li, (2014) for ten Asian-Pacific countries. Furthermore, some other studies have analyzed the volatility transmission between oil stock markets in Africa. For example, in a recent study, Lin, Presley and Micheal (2014) conducted a study to examine the volatility spillover between oil and the stock markets of Ghana and Nigeria. In addition to this, they computed the optimal weights and hedge ratios by using VAR-GARCH, VAR-AGARCH and DCC-GARCH results between 2000 and 2010. Their findings show significant unidirectional volatility spillover from oil to the stock markets of Ghana and Nigeria.

3. Data and Methodology

The daily closing prices of national indices for Balkan stock markets (Bulgaria, Greece, Romania and Turkey) were taken from Thomson Reuters Datastream and computed simple returns. The sampling is from 20.10.2000 to 08.02.2016. The Balkan stock market indices are: SOFIX for Bulgarian stock market, ATHEX for Greek stock market, BET for Romanian

stock market and BIST 100 for Turkish stock exchange. If a stock market of any country is closed at any specific day, then the data of that date is removed from all other countries.

We employed bivariate VAR(1)-GARCH(1) model, proposed by Ling and McAleer (2003) to explore volatility spillover effects between oil and Balkan stock markets. The VAR-GARCH model is based on the CCC-GARCH model of Bollerslev (1990). This model enables us to capture the long run volatility persistence and impact of past shocks. The VAR-GARCH model is also easy to use and it avoids the computational complications in estimating the unknown parameters. For each combination of oil and Balkan stock market, the VAR (1)-GARCH (1) model has the following conditional mean and variance;

$$Y_t = \mu + \Phi Y_{t-1} + \varepsilon_t \tag{1}$$

$$\varepsilon_t = H_t^{1/2} \eta_t$$

where:

- $Y_t = r_t^s$ and r_t^o are the returns of Balkan stock markets and oil return, respectively
- $\varepsilon_t = \varepsilon_t^s$ and ε_t^o are the residual terms of the mean equation
- $\eta_t = \eta_t^s$ and η_t^o refer the random vectors
- $H_t = \text{Diag} \sqrt{h_t^s} \times h_t^o$ are the conditional variances

$$h_t^o = C_o + \alpha_o(\varepsilon_{t-1}^o)^2 + \beta_o h_{t-1}^o + \alpha_s(\varepsilon_{t-1}^s)^2 + \beta_s h_{t-1}^s \tag{2}$$

$$h_t^s = C_s + \alpha_s(\varepsilon_{t-1}^s)^2 + \beta_s h_{t-1}^s + \alpha_o(\varepsilon_{t-1}^o)^2 + \beta_o h_{t-1}^o \tag{3}$$

Equations (3) and (4) estimate the way of transmitting volatility between oil and the Balkan stock market returns. The error terms, $(\varepsilon_{t-1}^o)^2$ for oil and $(\varepsilon_{t-1}^s)^2$ for stock, capture the effect of a direct shock. The volatility interdependence is estimated by h_{t-1}^o for oil and h_{t-1}^s for stock market. For the stationarity, the roots of the equation $[I_2 - AL - BL] = 0$ must be outside the unit circle.

Where L = lag polynomial,

$$I_2 = \text{identity matrix and } A = \begin{pmatrix} \alpha_{s1}^2 & \alpha_{s2}^2 \\ \alpha_{o2}^2 & \alpha_{o1}^2 \end{pmatrix} \quad B = \begin{pmatrix} \beta_{s1}^2 & \beta_{s2}^2 \\ \beta_{o2}^2 & \beta_{o1}^2 \end{pmatrix}$$

In the presence of conditional correlation, the conditional covariance between oil and Balkan stock markets can be computed as;

$$h_t^{s,o} = \rho \times \sqrt{h_t^s \times h_t^o} \tag{4}$$

where: ρ = conditional correlation coefficient

Overall, this model computes conditional mean and volatilities between oil and stock returns to capture the interdependence and spillover effects. The parameters of VAR-GARCH (1,1) model are estimated by log likelihood function L and optimized by the Broyden, 1970; Fletcher, 1970; Goldfarb, 1970; and Shanno, 1970 (BFGS) algorithm for a sample of T observations.

$$L = \sum_{t=1}^T L_t, L_t = \ln(2\pi)n/2 - 1/2 \ln|H_t| - 1/2 \varepsilon_t' H_t^{-1} \varepsilon_t \tag{5}$$

4. Empirical Findings

Table 2 demonstrates the descriptive statistics for oil and the Balkan stock market returns. The average returns are generally positive. The only exception is the Greek stock market

which has the lowest average return (-0.0003). This can be attributed to Greek government-debt crisis which occurred in late 2009. The highest average stock return occurs in Romania (0.0008), Turkey (0.0007), and Bulgaria (0.0005), respectively. The volatility of oil (measured by standard deviation) is higher than that of Balkan stock markets. The skewness coefficients are positive for oil and the stock markets of Bulgaria and Turkey. The kurtosis coefficients are greater than three, indicating that all series are leptokurtic. Moreover, the Jarque-Bera test rejects the null hypothesis of normality for both oil and the Balkan stock return series. The Q test results indicate evidence of autocorrelation in the return series of oil and Balkan stock markets. Lastly, the null hypothesis of no ARCH-LM effect is rejected at 1% significance level. This finding enables us to employ GARCH approach to investigate the return and volatility transmission between oil and the Balkan stock market returns.

Table 2

Descriptive Statistics for Balkan Stock Markets and Oil

Country	Bulgaria	Greece	Romania	Turkey	Oil
Mean	0.0005	-0.0003	0.0008	0.0007	0.0002
Std. Dev.	0.016	0.019	0.0162	0.022	0.0250
Min.	-0.188	-0.162	-0.122	-0.181	-0.157
Max.	0.234	0.143	0.1223	0.194	0.1783
Skewness	0.241	-0.134	-0.304	0.192	0.0651
Kurtosis	31.030	6.653	7.4961	7.628	4.714
Jarque-Bera	143827.42***	6621.14***	8446.88***	8712.11***	3322.23***
Q (12)	92.275***	24.915***	72.387***	21.169***	39.128***
ARCH-LM	259.322	253.884	477.735	533.227	429.925
# of Obs	3584	3584	3584	3584	3584

Note: ***, ** and * denote that coefficients are significant at 1%, 5% and 10% levels, respectively. Jarque-Bera test is used to test normality. ARCH test is used for conditional heteroskedasticity. Q test is the empirical statistics of the Ljung-Box tests for autocorrelations.

Table 3 shows the unit root tests with trends and without trends.

Table 3

Unit Root Test Results for Balkan Stock Markets and Oil

Country	With Trends			Without Trends		
	ADF	PP Test	KPSS	ADF	PP Test	KPSS
Bulgaria	-58.754***	-58.929***	0.261	-58.637***	-58.819***	1.017
Greece	-57.528***	-57.523***	0.099	-57.527***	-57.513***	0.170
Romania	-53.840***	-53.755***	0.137	-53.751***	-53.664***	0.799
Turkey	-58.982***	-59.015***	0.037	-58.984***	-59.008***	0.080
Oil	-61.278***	-61.294***	0.103	-61.253***	-61.260***	0.299

Note: ***, ** and * denote that coefficients are significant at 1%, 5% and 10% levels, respectively. The critical values with trends for ADF and PP are -3.9661, -3.4137 and -3.1286 respectively. The critical values without trends for ADF and PP are -3.4352, -2.8629 and -2.5675 respectively.

The tests of ADF, PP and KPSS are used to check the presence of unit root. While the null hypothesis for ADF and PP states that there is no unit root in the series, the null hypothesis

of KPSS is the reverse. The results of ADF and PP tests allow us to reject the null hypothesis, indicating that all return series are stationary at 1%. For the KPSS test, the null hypothesis is accepted. All test results are in the same line, suggesting that all return series are having a stationary process.

Figure 1 displays returns for the Balkan stock markets and WTI oil. The return series exhibit the volatility clustering leading to excess kurtosis as evident in Table 1 for all the cases. In particular, the stock returns of Bulgarian and Turkish stock markets have high volatility during 2000 and 2001. This can be attributed to financial turmoils in these markets. While Bulgaria experienced tough economic transition process in the early 2000s, Turkey had banking crisis in 2001. Moreover, there are common trends between oil and the Balkan stock markets during the 2007-2009 global financial crisis. It is obvious from Figure 1 that both oil and stock prices follow similar patterns during the global financial crisis. Among the stock markets, Greek stock market exhibits high volatility even after the global financial crisis. This can be explained by Greek government-debt crisis which occurred in late 2009. The Greek economy was shaken by heavy debt burdens and the stock market suffered heavy losses.

Figure 1

Return Graphs of Oil and Balkan Stock Markets

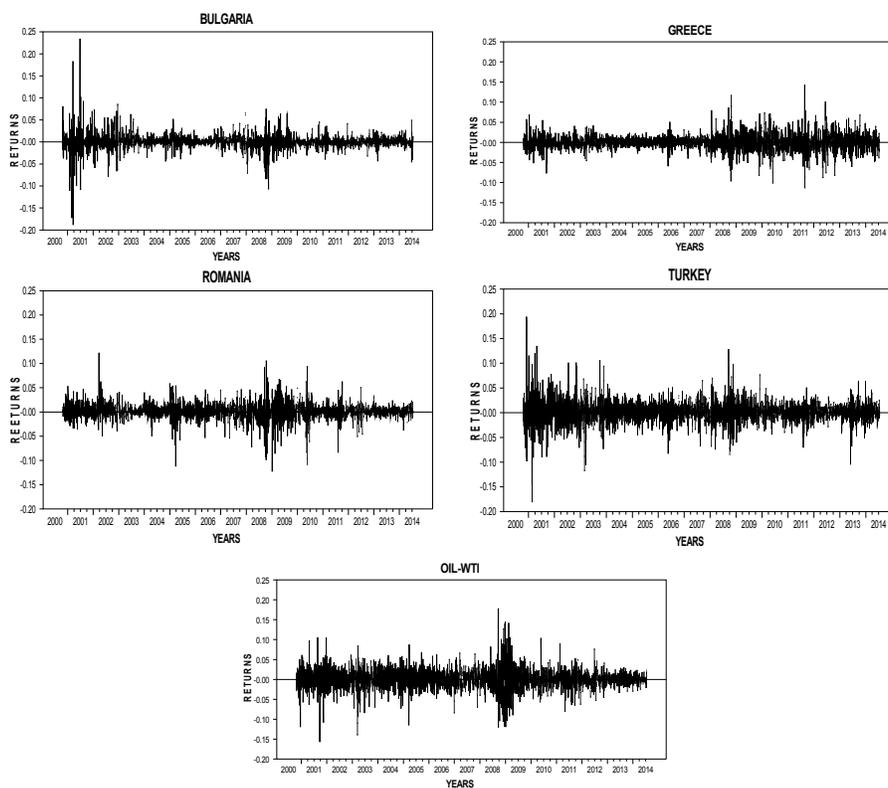


Table 4 summarizes the empirical findings of the estimated VAR(1)–GARCH(1) model for volatility spillover between oil and the Balkan stock markets. The terms h_{t-1}^{Oil} and h_{t-1}^{Stock} describe the conditional variances of the oil and the Balkan stock markets at time t respectively. The values of $(\varepsilon_{t-1}^{Oil})^2$ and $(\varepsilon_{t-1}^{Stock})^2$ show the impact of shocks of oil and the Balkan stock markets at time $t-1$ respectively. According to mean equation, one-period lagged oil returns significantly affect only the Turkish stock market. This implies that past oil returns help to predict the stock returns in Turkish stock market. There is no significant evidence for the rest of the Balkan stock markets, implying that past oil returns do not help in predicting short-term dependence. For the opposite direction, one-period lagged Bulgarian stock market returns have significant impact on the current oil returns.

The findings show that most of the ARCH and GARCH coefficients of Balkan stock markets are statistically significant at different levels. The estimates of ARCH and GARCH coefficients capture shock dependence and volatility persistence in the conditional variance equations. The results document that the past shocks of oil significantly affect the volatility of all observed Balkan stock returns. It seems that past oil shocks lead to enhance stock market volatility in the observed Balkan stock markets. This finding is consistent with Arouri, Jouini and Nguyen, (2012) who found that the observed volatility spillover effects in European stock markets come from past oil shocks.

The estimates of past shocks of oil $(\varepsilon_{t-1}^{Oil})^2$ affect the return dynamics of concerned stock markets. This implies that a past shock from oil market increases stock market volatility of observed Balkan countries. Further, the past shocks of Balkan stock markets $(\varepsilon_{t-1}^{Stock})^2$, are found negatively significant. The findings further present that the past conditional volatility of oil, h_{t-1}^{Oil} , is significant for Greece, Romania and Turkey at 1% level, respectively. This implies that the past volatility of oil is transmitted to the stock markets of Greece, Romania and Turkey. As for the opposite direction, the volatility cross effects, h_{t-1}^{Stock} , run from Balkan stock markets to oil in most cases except Greece.

Turning out to the estimates of the constant conditional correlation, we find that Balkan stock returns are positively correlated with WTI oil returns. However, the magnitudes of the correlations are generally low. The highest correlation between oil and stock market returns occurs in Turkey (0.11), followed by Romania (0.105), Greece (0.095) and Bulgaria (0.058), respectively.

These low correlations between oil and stock returns suggest that investors can earn potential returns by investing in the Balkan stock markets and oil asset. In particular, investing in Oil-Bulgarian stock portfolio might be attractive for investors for reducing the risk of their portfolios. Overall, the findings suggest that the significant volatility cross effects between oil and the Balkan stock markets require portfolio managers to quantify the optimal weights and hedging ratios to deal properly with stock investment risk. Therefore, we calculated the optimal weights and hedge ratios in the next section.

Table 4

Estimates of VAR(1)-GARCH(1) model for Balkan Stock Markets and Oil

	Bulgaria		Greece		Romania		Turkey	
Mean Eq	Oil	Bulgaria	Oil	Greece	Oil	Romania	Oil	Turkey
Oil (1)	-0.035** (0.02)	0.028 (0.13)	-0.028** (0.04)	0.002 (0.87)	-0.026*** (0.00)	0.020 (0.45)	-0.019* (0.06)	0.027*** (0.00)
Stock(1)	0.004** (0.02)	0.099*** (0.00)	-0.009 (0.30)	0.055*** (0.00)	0.008 (0.19)	0.068*** (0.00)	-0.008 (0.43)	0.041*** (0.00)
Variance Equation								
$C(10)^4$	0.470*** (0.00)	0.010*** (0.00)	0.037*** (0.00)	0.012*** (0.00)	0.570*** (0.00)	0.123*** (0.00)	0.016*** (0.00)	0.110*** (0.00)
$(\varepsilon_{t-1}^{oil})^2$	0.297*** (0.00)	0.044*** (0.00)	0.046*** (0.00)	0.017*** (0.00)	0.192*** (0.00)	-0.031*** (0.00)	0.086*** (0.00)	-0.014*** (0.00)
$(\varepsilon_{t-1}^{stock})^2$	-0.003*** (0.00)	0.135*** (0.00)	-0.001 (0.31)	0.060*** (0.00)	-0.007*** (0.00)	0.355*** (0.00)	0.001 (0.18)	0.1242*** (0.00)
h_{t-1}^{oil}	0.674*** (0.00)	0.005 (0.39)	0.949*** (0.00)	-0.017*** (0.00)	0.670*** (0.00)	0.120*** (0.00)	0.905*** (0.00)	0.028*** (0.00)
h_{t-1}^{stock}	0.004*** (0.00)	0.872*** (0.00)	0.0001 (0.89)	0.941*** (0.00)	0.016*** (0.00)	0.657*** (0.00)	0.003*** (0.00)	0.852*** (0.00)
CCC Oil & Stock	0.058*** (0.00)		0.095*** (0.00)		0.105*** (0.00)		0.110*** (0.00)	
Log Like	19215.7927		18164.3247		18847.3818		17594.7891	
AIC	-9.951		-9.555		-9.976		-9.327	
H-Q	-9.943		-9.550		-9.970		-9.326	

Note: The bivariate VAR(1)-GARCH(1,1) model is estimated for each Balkan country from October 20, 2000 to February 08, 2016. The Stock refers Balkan stock markets. The p-values are given in parentheses. The optimal lag order for the VAR model is selected using the AIC and H-Q information criterias. ***, ** and * denote that coefficients are significant at 1%, 5% and 10% levels, respectively.

4.1. Portfolio Management and Hedging Strategies

This section presents portfolio construction and hedging on the basis of findings of VAR(1)–GARCH(1) model discussed above. Let us construct an optimal portfolio of oil and stock to verify the estimates of VAR (1)–GARCH (1) model. In pursuit of Kroner and Ng (1998), the optimal weight of stock in a one- dollar portfolio of oil-stock at time t is given by:

$$W_t^{Stock,Oil} = \frac{h_t^{stock} - h_t^{Stock,oil}}{h_t^{stock} - 2h_t^{Stock,Oil} + h_t^{oil}}$$

and

$$\left\{ \begin{array}{l} 0 \text{ if } W_t^{Stock,Oil} < 0 \\ W_t^{Stock,Oil} \text{ if } 0 \leq W_t^{Stock,Oil} \leq 1 \\ 1 \text{ if } W_t^{Stock,Oil} > 1 \end{array} \right.$$

where: $W_t^{Stock,Oil}$ refers to the weight of stocks in a one-dollar portfolio of the two assets at time t . The conditional variances between oil and the stock returns of Balkan countries are measured by h_t^{oil} and h_t^{stock} . The term $h_t^{Stock,Oil}$ provides conditional covariance between oil and the Balkan stock markets at time t . The proportion of oil is calculated by $1 - W_t^{Stock,Oil}$. To compute the optimal hedge ratios, we followed Kroner and Sultan (1993) who computed optimal hedge ratios to minimize risk. Investors need to know that how much a long position (buy) of one-dollar in the stock market should be hedged by a short (sell) position of β_t dollar in the oil asset.

Kroner and Sultan (1993) proposed the hedge ratio in following way:

$$\beta_t^{Stock,Oil} = \frac{h_t^{Stock,Oil}}{h_t^{oil}}$$

Table 5 demonstrates the summary statistics for the portfolio weights, $W_t^{Stock,Oil}$, and the hedge ratios, $\beta_t^{Stock,Oil}$, produced by the VAR(1)–GARCH(1) model. The optimal weights range from 56 % for Turkey to 76% for Bulgaria. For Bulgaria-Oil portfolio, the optimal weight of the Bulgarian stocks in a one-dollar Bulgaria-oil portfolio should be 76%, the rest (24%) should be invested in oil. The optimal weight of stocks is 73 cents, and the remainder of 27 cents should be invested in oil for the Romanian stock market. Overall, investors should invest more proportion of their portfolio in the Balkan stock markets than oil assets to minimize the risk.

Table 5
Summary Statistics for the Portfolio Weights and Hedge Ratio

	$W_t^{Stock,Oil}$	$\beta_t^{Stock,Oil}$
Bulgaria- Oil	0.76	0.12
Greece- Oil	0.62	0.14
Romania- Oil	0.73	0.19
Turkey- Oil	0.56	0.13

Note: The table reports average optimal weights and hedge ratios for all stock markets.

In general, the average optimal hedge ratios are low. This finding implies that oil can be used to take a short position. This finding is consistent with Arouri, Jouini and Nguyen, (2012), Lin *et al.* (2014) who support the view that stock market investment risk can be hedged by taking

a short position in oil asset. The hedge ratios range from 12% (Bulgarian stock market) to 19% (Romanian stock market). This finding suggests that while a one-dollar long position in the Bulgarian stock market should be hedged with a short position of 12 cents in the oil, a one-dollar long position in the Romanian stock market should be hedged with a short position of 19 cents in the oil. High hedge ratio of Romanian stock market implies that there are limited diversification opportunities.

5. Conclusion

The growing importance of emerging economies accompanied with the increased importance of oil presents new opportunities for investors to design their portfolios. In this study, we have attempted to explore volatility spillover between WTI oil and four Balkan stock markets including Romania, Bulgaria, Greece and Turkey. For this purpose, we employed VAR-GARCH model using daily closing prices of national stock indices from October 20, 2000 to February 8, 2016. Moreover, we calculated optimal weights and hedge ratios for oil-Balkan stock portfolio holdings.

The findings show significant volatility spillover between WTI oil and Balkan stock market returns. The stock prices are sensitive to fluctuations in oil prices. Not only the current oil prices but also the past oil prices have significant impact on the volatility of stocks. In particular, the transmission of volatility is more apparent from past oil shocks to stock returns. This implies that past oil shocks have significant impact in determining the future volatility for the Balkan stock markets.

The findings further show significant and positive correlations between Balkan stock markets and oil. The positive correlations between Balkan stock markets and oil suggest that Balkan stocks and oil respond similarly to changes in demand. However, the magnitude of the correlations are low for oil-Balkan stock portfolio holdings. The low correlations imply portfolio diversification and hedging opportunities for the investors. Among the four investigated Balkan countries, the portfolio of Oil-Bulgaria stocks can be the most attractive portfolio for the investors, since this portfolio has the lowest conditional correlation.

Considering the optimal weights and hedge ratios, the findings suggest that investors should better invest a larger portion of their portfolios in Balkan stock markets than in oil. Investors can hedge the stock investment risk effectively by using oil asset in their portfolios.

Overall, our results have important implications for forecasting the future oil and stock market return volatility, making optimal portfolio allocation decisions for energy traders and stock investors. For investors, who hold oil and stocks from four Balkan countries, it is important to monitor the correlation levels between stock returns and oil. For the future research avenue, it would be interesting to extend this study that allows examining the volatility spillover between oil and other Balkan stock markets.

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