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DO NEGATIVE OIL PRICE SHOCKS AFFECT THE INDUSTRIAL SECTOR STOCK PRICES MORE THAN POSITIVE SHOCKS? A BIVARIATE EGARCH ANALYSIS FOR TURKEY[*]

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ABSTRACT

This paper investigates the asymmetric volatility spillover from oil prices to Turkish industrial main and sub-sectors' stock prices and Borsa Istanbul 100 index (BIST 100) as a whole. A bivariate VAR-EGARCH model is employed to the daily return data cover the period between August 3rd, 2009 and June 30th, 2016. Results show that there are asymmetric volatility spillovers from oil returns to all of the industrial sector returns as well as the BIST 100 index returns except mining sector. These findings imply that the negative shocks in the oil returns affect the industrial sector returns more than positive shocks.

Keywords: *Oil prices; Turkish industry sector; Asymmetric volatility spillover*

NEGATİF PETROL FİYAT ŞOKLARININ SANAYİ SEKTÖRÜ ÜZERİNE ETKİSİ POZİTİF FİYAT ŞOKLARINDAN FAZLA MIDIR? TÜRKİYE ÜZERİNE İKİ DEĞİŞKENLİ EGARCH ANALİZİ

ÖZ

Petrol dünyada en çok takip edilen emtia olma özelliğine sahiptir. Gerek arz ve talebi gerekse bunun sonucu olarak fiyatları bakımından petrol yalnızca makroekonomik göstergeler üzerinde değil aynı zamanda finansal piyasalar üzerinde de etkin bir rol oynayan bir değişkendir. Bu çalışmada petrol fiyatlarından Türkiye'deki toplam ve alt sektörler bazında Borsa İstanbul'da işlem gören sanayi sektörüne ait hisse senedi fiyatlarına doğru asimetrik oynaklık yayılımının olup olmadığı incelenmiştir. Bu bağlamda, 03.08.2009-30.07.2016 tarihleri arasında günlük olarak derlenen ve getiri serisi haline dönüştürülen veri setine iki değişkenli VAR-EGARCH modeli uygulanmıştır. Elde edilen sonuçlara göre, petrolden madencilik sektörü hariç tüm sektörlere ve BİST 100 endeksine doğru asimetrik bir oynaklık yayılımı vardır. Buna göre petrol fiyatlarında meydana gelen negatif oynaklıkların hisse senetleri üzerinde pozitif olanlara göre daha fazla etkisi olduğu söylenebilir.

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Anahtar Kelimeler: Petrol fiyatları; Türk sanayi sektörü; Asimetrik oynaklık yayılımı

1. INTRODUCTION

While the world is trying to find alternative sources to meet the increasing need for energy, oil is still the most important input of energy. The individuals need oil to start their car's engine while the companies also need oil to keep their machines working. The share of oil used as the source of primary energy is about 32 percent in 2015. With natural gas, which is a derivative of oil, the share rises up to about 56 percent (BP Energy Outlook, 2017: 14). Therefore, oil and its derivatives are indispensable for almost all industries that operate today.

This study aims to investigate the effect of oil price fluctuations on industry sector and Borsa Istanbul (BIST) as a whole. More specifically the asymmetric volatility spillovers from oil return to industry sector and BIST returns are investigated in this study. This study also tries to reveal the length of the persistence and the size of this spillover effect. Eventually, this will help risk takers to make healthier investment decisions and predict possible risks that caused by global oil price shocks and fluctuations.

As it is well known that oil is one of the most monitored commodities at the present time. This is reasonable since oil, as an energy and raw material input, is an important cost item for several industries in an economy. As a result, it is inevitable to have an impact of oil price shocks on industries as well as on the whole economy. Oil price shocks will affect countries in different ways depending on whether they are net oil exporters or net oil importers. For instance, Russia, as a net oil exporter, will be affected negatively by a decrease in oil prices, while Turkey will be affected positively, in macro economical manner.

On the other hand, oil supply and demand, which are the main determinants of the oil prices, are also seen as an indicator of the general view of the world economy. Within this scope, an increase in the oil demand will be seen as an economic recovery while a decrease will be seen as economic stagnation. Thus, the economic agents make investment decisions by taking oil price movements into consideration.

Yet another theory that tries to explain the possible relationship between oil prices and asset prices is the financialization of oil. According to this theory, oil is increasingly becoming a financial investment tool rather than a commodity. Consequently, hedge funds, pension funds, insurance companies, and retail investors include oil to their portfolio. Moreover, the financialization is also the cause of increased oil price volatility and higher oil price co-movement with several financial asset prices.

Industry sector is expected to be affected by oil price fluctuations more than others such as services or financial sectors. Especially in oil importing countries like Turkey, industry sector will benefit from falling oil prices. On the contrary, rising oil prices will also raise firms' costs so that the whole sector will face demand and profit losses in the long-run. On the other hand in oil producing and exporting countries, the effects of rising oil prices on the industry sector will be somewhat different. Non-oil producing firms' costs in such countries will also rise in return for a positive oil price shock and eventually this will affect the industry negatively. On the contrary, oil-producing firms will gain more profit and produce capital that can be canalized into investments in such conditions. This will also boost all the related firms' production and eventually the country's economy in general.

The main motivations of this study are to find out: (1) if there is an asymmetric volatility spillover from oil return to BIST 100 index returns, (2) if there is an asymmetric volatility spillover from oil return to industry sector return as a whole, (3) if there is an asymmetric volatility spillover from oil return to industries' returns separately, (4) the size of the asymmetric impact and length of the volatility persistence.

The sample covers the daily returns of Brent oil, BIST 100, industry main sector and industry sub-sectors (food, textile, paper, chemical, stone, ore, machine, and mining) from August 3rd, 2009 to June 30th, 2016. The date starts in mid-2009 in order to avoid the possible effects of the 2007-2008 global financial crisis on the data set. Despite the fact that there is a significant body of research exists on the volatility spillover, this study separates since it takes sub-sectors in Turkey and uses EGARCH to catch asymmetry in the volatility spillover for the first time to the best of our knowledge.

The literature review follows this section. In Section 3 econometric methods are presented. Then data set and preliminary statistics are introduced in Section 4. Results and discussions are revealed in Section 5 and finally, in Section 6 a brief summary of this study and suggestions are discussed.

2. LITERATURE REVIEW

In their paper, Chen et al. (1986) have tested whether shifts in macroeconomic variables, as well as oil prices, affect the stock market (New York Stock Exchange) in the USA. Using capital asset pricing model (CAPM), they found that there is no relationship between oil prices and the stock market. Sadorsky (1999) on the other hand, has found evidence from GARCH model, impulse-response functions and variance decomposition analysis that oil prices and oil price volatility play important roles in affecting stock returns and economic activity asymmetrically.

Basher and Sadorsky (2006) have employed an international multi-factor model, which is related to the international CAPM. They have used daily closing prices of 21 emerging stock markets that cover the period from December 31, 1992 to October 31, 2005. The results have shown that oil price risk affects stock prices in selected emerging markets. Linn (2009) have addressed the effect of oil prices on manufacturing industries in the USA, in three different ways. These are direct, supply and demand effects. The direct effect suggests that the costs of energy-intensive industries will rise as oil prices increase. According to supply effect, industries that use energy-intensive inputs experiences increase in material prices after an upward oil price shock. Finally, the demand effect suggests that the demand for an industry's oil intensive products decrease as oil prices increase. Results show that oil price shocks affect average production per plant but don't have any significant effect on entry and exit.

Henriques and Sadorsky (2008) and Schmitz (2009) have analyzed the nexus between oil prices and stock prices of alternative energy companies in the USA. To do so, they have employed a vector autoregression (VAR) model and CAPM-GARCH multi-factor market model to the weekly data for the period of 2001-2007 and 2006-2009 respectively. In conclusion, they both have found that oil prices have significant effects on the stock prices of alternative energy companies.

Park and Ratti (2008) have investigated the effect of oil price shocks on stock markets of the USA and 13 European countries for the period of 1986:01-2005:12. They have found evidence of contemporaneously and statistically significant effect of oil price shocks on stock returns from the results of their unrestricted VAR analysis. Arouri and Nguyen (2010) have tested the linkage between oil prices and stock prices with multi-factor CAPM and Granger Causality analysis for 18 European countries. Their results show that an increase in oil prices has positive impacts on finance, oil, and gas, industrials, raw materials and services sectors, while it has negative impacts on food and beverages, healthcare and technology sectors. Nonetheless, they have found no evidence of a relationship between oil prices and personal and household goods, telecommunication and utility sectors. Torul and Alper (2010) have analyzed the responses of the manufacturing industry and sub-sectors to the oil price movements in Turkey for the period between 1991 and 2007 by employing VAR model. According to their results in general manufacturing industry does not respond to oil price movements significantly.

Fukunaga et al. (2010) have first decomposed oil into its components and then analyzed the dynamic effects of each component on industries' production and prices in the USA and Japan. To do so they employed identified VAR model. As a result, they found that an increase in global oil demand increases the prices of most industries such as petroleum refineries and automotive products in the USA as well as in Japan. By employing a generalized VAR-GARCH model, Arouri et al. (2011) have investigated the volatility transmission between oil and stock markets in the Gulf Cooperation Council (GCC) countries for the period of 2005-2010. They found that oil price movements significantly affect the stock returns in Bahrain, Oman, and Qatar.

Filis et al. (2011) have investigated the time-varying correlation between oil and stock market prices for both oil-importing (USA, Germany, The Netherlands) and oil-exporting (Canada, Mexico, Brazil) countries. They have employed a Dynamic Conditional Correlation Asymmetrical GARCH

(DCC-GARCH-GJR) approach to analyze the above relationship for the period of 1987-2009. Consequently, they found that the correlation increases in respond to demand-side oil price shocks in all countries. Falzon and Castillo (2013) have investigated effects of the oil prices on the S&P 500 in the USA and FTSE in the United Kingdom by employing a GARCH model for the period between 1973:01 and 2011:05. According to their results volatility of oil prices affects the volatility of the selected indexes.

In one of the more recent studies, Dhaoui and Khaief (2014) examined empirically whether oil price shocks affect stock market returns in eight developed countries for the period of 1991:01-2013:09. Their EGARCH-M analyzes revealed that there is a strong negative relationship between oil prices and stock market returns in seven of the selected countries. Gomes and Chaibi (2014) have tested the volatility spillover from oil prices to selected 21 stock market indexes for the date between 2008 and 2013. They have employed a BEKK-GARCH model in order to analyze the relationship and found that there is volatility spillover from oil prices to stock market prices of Kuwait, Qatar, Nigeria and the United Arab Emirates.

Gencer and Demiralay (2014) have examined the shock and volatility spillovers between the oil market and five selected sectors in Turkey. They have employed a bivariate GARCH model to investigate the aforementioned relationship with the daily return data spanning from January 4, 2005, to June 12, 2013. Their results suggest that there is significant unidirectional volatility transmission from oil returns to sectors returns as well as BIST 100 index. Sattary et al. (2014), have also examined the possible volatility spillover between oil market and several sector indices operating in BIST 100, such as energy, non-metal mineral products, and transportation sectors. Like Gencer and Demiralay (2014), Sattary et al. are also conducted a bivariate GARCH model to estimate the relationship between series. Eventually, they found that except non-metal sector, there are interactions between oil and sector returns including BIST 100 general index.

Taulon and Guesmi (2014) have investigated the relationship between oil prices and stock prices in the oil-exporting and developing four countries namely Venezuela, United Arab Emirates, Saudi Arabia and Kuwait. To do so they have employed DCC-GARCH model for the period of 2000-2010. Their results show that there are significant relationships between oil prices and these stock market prices. Finally, Phan et al. (2015) have examined how differently stock returns of total 20 oil producers and oil consumers are affected from oil price movements in the USA for the period between 1986 and 2000. By employing GARCH models they have found that by contrast with oil consumers, stock returns of oil producers are affected positively by oil prices changes symmetrically.

3. ECONOMETRIC METHODOLOGY

In time series analyzes it is crucial to work with stationary data in order to avoid spurious relationship between the series. In this study, Phillips Perron (PP) unit root test is employed to analyze whether the data is stationary or not. PP is a non-parametric and robust unit root test to any possible heteroscedasticity in the error term. The constant with trend model that suggested by Phillips and Perron (1988:338-343) is;

$$\Delta Y_t = \beta_0 + \beta_1(t - T/2) + \alpha_1 Y_{t-1} + \upsilon_t \tag{1}$$

Where "β_0", "β_1", and "α_1" are the conventional least-squares regression coefficients and "υ_t" is moving average error that is written explicitly as $\upsilon_t = \varepsilon_t + \theta\varepsilon_{t-1}$. Since the data that used in this paper is heteroscedastic, PP unit root test is employed in order to check stationarity.

As it is mentioned in earlier sections, the aim of this study is to investigate the asymmetric volatility spillover from oil price returns to industries' stock price returns. Thus the Exponential Generalized Autoregressive Conditional Heteroscedasticity (EGARCH) model that is developed by Nelson (1991) is used. One of the key advantages of EGARCH model is the variance is positive since Nelson describes it in logarithmic form. Thus coefficients must not be positive unlike the other GARCH models such as GJR-GARCH and TGARCH (Hamilton, 1994:668).

Following Koutmos and Booth (1995) and Kanas (1998), a bivariate EGARCH model is employed in order to examine asymmetric volatility spillover from oil to sectors. The model is defined as follows:

$$S_t = \beta_0 + \sum_{k=1}^{m} \beta_{p,i} P_{t-k} + \sum_{k=1}^{m} \beta_{s,i} S_{t-k} + \varepsilon_t \tag{2}$$

$$\ln(\sigma_{s,t}^2) = \alpha_0 + \lambda_s f(z_{s,t-1}) + \sum_{i=1}^{p} \gamma_{s,i} \ln(\sigma_{t-i}^2) + \delta_p f(z_{p,t-1}) \tag{3}$$

$$f(z_{s,t-1}) = \theta_s z_{t-1} + \phi(|z_{t-1}| - E|z_{t-1}|) \tag{4}$$

$$f(z_{p,t-1}) = \theta_p z_{t-1} + \phi(|z_{t-1}| - E|z_{t-1}|) \tag{5}$$

Equation (2) is the conditional mean equation of the model where S_t is stock returns, P_t is oil returns, which also measures the extent of price spillover from oil to sectors, and ε_t is the white noise errors. It is specified as a Vector Autoregressive (VAR(k)) model. The optimal lag length is selected by taking the Akaike and Schwartz Information Criteria and White Noise properties of the residuals into account.

Equation (3) is the conditional variance equation of the EGARCH(p, q) model. EGARCH(2,1) is tested against EGARCH(1,1) by using Likelihood Ratio (LR) test in order to determine the p lag length. In this model, δ_p is the coefficient of volatility spillover from oil to related sectors. The persistence of the volatility is measured by $\sum_{i=1}^{p} \gamma_{s,i}$. The parameter λ_s is the ARCH coefficient of the stocks.

In Equation (4) and (5), θ_p and θ_s parameters give information about the asymmetry of spillover and ARCH effects respectively. For instance, a negative and statistically significant θ_p indicates that negative shocks in oil prices increase the volatility of stock prices more than positive shocks. Finally, the parameters of $z_{s,t-1}$ and $z_{p,t-1}$ are the lagged standardized residuals ($\varepsilon_{sp,t-1}/\sigma_{sp,t-1}$) of both oil and stocks respectively in Equation (3).

4. DATA AND PRELIMINARY STATISTICS

Daily closing values[1] of Brent crude oil spot prices per barrel in US dollars and BIST general index, industry sector and sub-sectors stock prices are employed in this paper. The data are collected from US Energy Information Administration (EIA) web site and BIST Data Store for the period between August 03, 2009 and June 30, 2016, a total of 1725 observations[2]. The data start from mid-2009 in order to avoid the potential effects of 2007-2008 global financial crisis, especially on stock prices. The logarithmic difference of the data is calculated ($R_{i,t} = ln(P_{i,t}) - ln(P_{i,t-1})$) in order to get return values and capture the volatility spillover between the series. $R_{i,t}$ is the return value of the series i in the time t while $P_{i,t}$ is the price value of the same series. All the codenames that are used in the paper of the data are shown in Table 1.

Table 1. Data and Codenames

Order	Codenames	Data description and sectors
1	**brent**	**Brent crude oil**
2	**xu100**	**BİST 100 general index**
3	**xusin**	**Industry main index**
3.1	xgida	Food and beverage
3.2	xteks	Textile and leather
3.3	xkagt	Forestry and paper
3.4	xkmya	Chemistry and petroleum
3.5	xtast	Stone and soil
3.6	xmana	Main metal
3.7	xmesy	Metalware
3.8	xmadn	Mining

Source: Public Disclosure Platform (PDP) website.

The descriptive statistics of the return series are shown in Table 2. The average daily return values are rather close to each other. The oil and mining sector returns are the only exceptions. The greatest positive average return is provided by the metalware sector while the negative is provided by

[1] Empty dates due to several reasons such as holidays, are filled with the arithmetic mean of its previous and the following values.
[2] The data of mining sector start from February 04, 2013 since the calculation begins at this date.

the mining sector. Besides, it can be seen that all series have high kurtosis values as expected, and this causes fat tails in the data series.

Table 2. Descriptive Statistics

Return Series	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis
dlnbrent	-0.000242	0.098961	-0.082452	0.018881	0.190158	5.992877
dlnxu100	0.000315	0.068952	-0.110638	0.014884	-0.499319	6.593290
dlnxusin	0.000536	0.064551	-0.114010	0.012542	-1.114831	11.72410
dlnxgida	0.000447	0.061214	-0.117955	0.015071	-0.668263	8.444007
dlnxteks	0.000589	0.089945	-0.139863	0.015132	-1.242607	14.04055
dlnxkagt	0.000289	0.073802	-0.115519	0.015785	-0.753679	8.112130
dlnxkmya	0.000618	0.070190	-0.093699	0.015384	-0.570586	6.363918
dlnxtast	0.000294	0.061957	-0.107729	0.013083	-1.041875	9.789352
dlnxmana	0.000550	0.092119	-0.109009	0.016936	-0.602908	7.080864
dlnxmesy	0.000853	0.090285	-0.141809	0.016074	-0.735784	10.27542
dlnxmadn	-0.001664	0.127970	-0.179664	0.027969	-0.323709	7.119804

On the other hand, all series except oil returns have negative skewness values, implying that there is a greater chance that the sectors to fall rather than rise in the given period of time. Finally, almost all sectors have experienced the minimum return values at the same date when is June 03, 2013. This indicates the negative effects of the demonstrations that took place in Istanbul at the end of the May 2013 on Borsa Istanbul.

5. EMPIRICAL FINDINGS

The PP unit root test results of the return series are reported in Table 3. As seen in the table all the return series are stationary. In Table 4 on the other hand, presents the selection results of the most appropriate VAR(k) models. The minimum Akaike and Schwarz Information Criteria (AIC and SIC respectively) and white noise properties of the residuals are taken into account to select the optimal lag length k. Consequently, VAR(1) model is tested against VAR(2) model and selected for all sectors. Another important point that can be seen in Table 4 is that ARCH-LM test statistics are significant at % 1 level which means all VAR models have heteroscedasticity. For most of the daily financial time series that is an expected situation. Besides the AR roots are in the unit circle that shows the stability of the models.

Table 3. PP Unit Root Test Results

Return Series	Constant	Constant with Trend
dlnbrent	-39.37308*	-39.39300*
dlnxu100	-42.10802*	-42.11662*
dlnxusin	-40.11704*	-40.14515*
dlnxgida	-42.83918*	-43.05984*
dlnxteks	-40.98124*	-41.01893*
dlnxkagt	-40.83975*	-40.85455*
dlnxkmya	-39.65755*	-39.68758*
dlnxtast	-39.63269*	-39.66050*
dlnxmana	-40.94596*	-40.93720*
dlnxmesy	-41.22060*	-41.22795*

dlnxmadn	-28.61777*	-28.60147*

* shows stationarity at 1% level of significance. Newey-West (1994) automatic bandwidth is used. Obtained t statistics are compared with McKinnon's (1990) critical values.

Table 4. Selection Results of the Most Appropriate VAR Models

VAR(*k*)	**AIC**	**SIC**	**Q**	**LM**	**AR Roots**
dlnxu100 (1)	-10.71964	-10.70065	4.013362	4.940468*	✓
dlnxusin (1)	-11.07568	-11.05670	2.929482	6.198931*	✓
dlnxgida (1)	-10.67523	-10.65625	4.387140	4.374736*	✓
dlnxteks (1)	-10.67648	-10.65749	1.789201	6.501728*	✓
dlnxkagt (1)	-10.58591	-10.56693	0.910843	5.885617*	✓
dlnxkmya (1)	-10.65732	-10.63833	6.542261	4.525751*	✓
dlnxtast (1)	-10.96547	-10.94649	0.331837	7.118238*	✓
dlnxmana (1)	-10.46203	-10.44305	4.015380	2.652259*	✓
dlnxmesy (1)	-10.56083	-10.54185	0.703276	5.271259*	✓
dlnxmadn (1)	-9.266772	-9.233245	3.782181	3.274545*	✓

* denotes significance at 1% level, Q and LM are the Portmanteau Adjusted Autocorrelation and ARCH-LM Heteroscedasticity F statistics respectively, ✓ means that the AR root in the unit circle.

After determining the order of VAR(k) model, a bivariate VAR-EGARCH model, which was defined in Section 3, is established to analyze the volatility spillover between oil and sectors. In this section, these bivariate EGARCH models for each of the oil and sector pairs are estimated and the obtained results are presented in Table 5 and 6.

In Table 5, it can be seen in the mean equation (Panel A) that there are no price spillover from oil to BIST 100 index, industry main index, textile, and forestry sectors. On the other hand, there is a weak price spillover from oil to food and beverage sector. Another important result that can be seen in Panel A there is at least a weak market efficiency in all sectors except textile sector. This means that investors could not forecast the future prices only with the information of current prices (Seyidoğlu, 2011:731).

The Panel B of the Table 5 reveals the results of the variance equations. According to the results, there is a volatility spillover between oil returns to all of the sector returns. Besides, the asymmetric spillover parameters are negative and statistically significant for all of the sectors which implies that a negative shock in oil prices increase the volatility in the sector stock prices more than a positive shock of an equal magnitude. In addition, there is an asymmetric ARCH effect for the BIST100, industry, food and forestry sectors. On the other hand, the ARCH effect for the textile sector is symmetric. Finally, it is observed that for all sectors the persistence of the volatility parameters are statistically significant.

The diagnostics are shown in the Panel C. As is seen in the Ljung-Box test statistics for all the EGARCH models indicate that there are no autocorrelation and heteroscedasticity in the residuals. Jarque-Bera statistics show that the residuals are not normally distributed. Thus the Bollerslev Wooldridge (1992) robust standard errors are applied in order to take care of this issue.

Table 5. Results of the Bivariate EGARCH Models (Part 1)

Parameters	dlnxu100	dlnxusin	dlnxgida	dlnxteks	dlnxkagt
Panel A. Mean Equation					
Price Spillover from Oil Returns to Sector Returns ($\boldsymbol{\beta_{p,1}}$)	-0.0097 (-0.5407)	0.0224 (1.5453)	0.0339 (1.8158)***	-0.0204 (-1.1611)	0.0021 (0.1310)
Price Informational Efficiency ($\boldsymbol{\beta_{s,1}}$)	0.0290 (1.1569)	0.0323 (1.1548)	-0.0348 (-1.3095)	0.0726 (1.8082)***	0.0234 (0.8084)
Constant Term of the Mean Equation ($\boldsymbol{\beta_0}$)	0.0005 (1.6073)	0.0009 (3.3234)*	0.0005 (1.4129)	0.0007 (2.3736)**	0.0002 (0.3864)
Panel B. Variance Equation					
Constant Term of the Variance Equation ($\boldsymbol{\alpha_0}$)	-1.2008 (-3.5031)*	-1.9184 (-4.8095)*	-1.7531 (-3.8310)*	-1.8920 (-4.8047)*	-2.0214 (-4.3378)*
ARCH effect ($\boldsymbol{\lambda_s}$)	0.1933 (3.6558)*	0.2299 (4.9424)*	0.2309 (4.7064)*	0.3996 (3.8610)*	0.4199 (5.3636)*
Asymmetry of ARCH effect ($\boldsymbol{\theta_s}$)	-0.1771 (-3.5000)*	-0.2801 (-4.2303)*	-0.1364 (-4.3389)*	-0.0452 (-0.9757)	-0.0815 (-1.7674)***
Volatility Persistence of Sectors ($\boldsymbol{\gamma_{s,1}}$)	0.5006 (2.6756)*	0.4048 (3.5668)*	0.8213 (16.4915)*	0.8230 (20.9224)*	0.8077 (15.7630)*
Volatility Persistence of Sectors ($\boldsymbol{\gamma_{s,2}}$)	0.3802 (2.1918)**	0.4092 (3.7540)*			
Volatility Spillover ($\boldsymbol{\delta_p}$)	0.0484 (2.1412)**	0.1049 (3.0792)*	0.0796 (2.0242)**	0.0926 (2.9307)*	0.1060 (3.6955)*
Asymmetry of the Spillover ($\boldsymbol{\theta_p}$)	-0.0926 (-2.4254)**	-0.1787 (-2.9140)*	-0.1479 (-2.1917)**	-0.1946 (-3.8482)*	-0.1590 (-3.6587)*
Panel C. Diagnostics					
LB (36)	24.478	40.400	34.638	37.302	29.113
LB^2 (36)	43.933	37.368	31.656	26.621	26.425
Jarque-Bera	229.48*	2002.36*	324.84*	1622.52*	515.51*
$LR_{egarch(2,1)}$	2.192**	3.754*	-0.898	-1.235	0.005
Log-likelihood	4904.41	5288.61	4901.52	4983.23	4879.98

*, **, *** denote statistically significance at 1%, 5% and 10% level respectively. Estimated z statistics are in the parenthesis. LB and LB^2 are the Q and Q^2 autocorrelation test statistics of Ljung-Box. LR_{garch}; (H_0: $\gamma_{s,2} = 0$).

Table 6 presents the EGARCH estimation results for chemistry, stone, main metal, metalware and mining sectors. It can be seen in the Panel A, there is a price spillover from oil to chemistry and main metal sectors. Furthermore, except chemistry, there is at least a weak market efficiency for the rest of sectors.

Parameters of the variance equation are shown in Panel B of Table 6. According to the results, there is an asymmetric volatility spillover from oil returns to chemistry, stone, main metal, and metalware sectors. On the other hand, the volatility spillover from oil returns to mining sector is not asymmetric. In addition, there is also a statistically meaningful ARCH effect in all sectors. These ARCH effects are asymmetric in all sectors but mining.

In Panel C, it can be seen that there is an evidence of a weak autocorrelation in the residuals of stone and soil sector. This problem could not be resolved by considering higher VAR order, therefore left as is. Although there seems a weak heteroscedasticity for chemical sector, the ARCH-LM test is applied and the result (LM=1.2651) confirmed that the model's residuals are free from heteroscedasticity. Jarque-Bera test statistics show that the hypothesis of normality is rejected for all of the series. This issue is handled by applying Bollerslev and Wooldridge's (1992) robust standard errors. A summary of all asymmetric volatility spillover (from oil) results is presented in Table 7.

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Table 6. Results of the Bivariate EGARCH Models (Part 2)

Parameters	dlnxkmya	dlnxtast	dlnxmana	dlnxmesy	dlnxmadn
Panel A. Mean Equation					
Price Spillover from Oil Returns to Sector Returns $(\boldsymbol{\beta_{p,1}})$	0.0330 (1.7320)***	-0.0001 (-0.0070)	0.0473 (2.1137)**	0.0055 (0.2833)	0.0683 (1.4078)
Price Informational Efficiency $(\boldsymbol{\beta_{s,1}})$	0.0471 (1.6870)***	0.0329 (1.1498)	0.0393 (1.4331)	0.0224 (0.7692)	0.0332 (0.7367)
Constant Term of the Mean Equation $(\boldsymbol{\beta_0})$	0.0007 (2.0553)**	0.0008 (2.9897)*	0.0008 (2.1229)**	0.0008 (2.5325)**	-0.0015 (-1.7994)***
Panel B. Variance Equation					
Constant Term of the Variance Equation $(\boldsymbol{\alpha_0})$	-1.5010 (-3.2653)*	-2.0245 (-4.4783)*	-2.1284 (-3.7443)*	-1.0581 (-3.6205)*	-1.0705 (-3.1494)*
ARCH effect $(\boldsymbol{\lambda_s})$	0.1863 (4.0371)*	0.3987 (4.5618)*	0.2301 (4.2194)*	0.2533 (4.4260)*	0.2202 (2.6143)*
Asymmetry of ARCH effect $(\boldsymbol{\theta_s})$	-0.1283 (-3.3129)*	-0.1198 (-2.0353)**	-0.1471 (-3.0202)*	-0.1228 (-3.0971)*	-0.0415 (-0.8386)
Volatility Persistence of Sectors $(\boldsymbol{\gamma_{s,1}})$	0.8434 (16.245)*	0.5300 (3.2255)*	0.3748 (2.4256)**	0.9014 (29.1910)*	0.8870 (22.0659)*
Volatility Persistence of Sectors $(\boldsymbol{\gamma_{s,2}})$		0.2822 (1.9192)***	0.3980 (2.7529)*		
Volatility Spillover $(\boldsymbol{\delta_p})$	0.0516 (2.0794)**	0.0830 (2.4353)**	0.1109 (2.8423)*	0.0486 (2.0203)**	0.1228 (2.2337)**
Asymmetry of the Spillover $(\boldsymbol{\theta_p})$	-0.0959 (-2.4311)*	-0.1859 (-3.6823)*	-0.1991 (-3.0298)*	-0.0878 (-2.2196)**	-0.0780 (-0.9632)
Panel C. Diagnostics					
LB (36)	34.536	50.495***	35.235	29.923	33.892
LB^2 (36)	47.510***	24.158	25.482	35.012	40.015
Jarque-Bera	618.19*	666.05*	689.10*	1329.26*	407.28*
$LR_{egarch(2,1)}$	1.369	1.919***	2.753*	-0.369	1.531
Log-likelihood	4839.96	5214.42	4667.68	4838.59	1879.73

*, **, *** denote statistically significance at %1, %5 and %10 level respectively. Estimated z statistics are in the parenthesis. LB and LB^2 are the Q and Q^2 autocorrelation test statistics of Ljung-Box. LR_{garch}; (H_0: $\gamma_{s,2} = 0$).

Table 7. Summary of VAR-EGARCH Models

Sectors	Volatility Spillover	Asymmetry
BİST 100 general index	✓	✓
Industry main index	✓	✓
Food and beverage	✓	✓
Textile and leather	✓	✓
Forestry and paper	✓	✓
Chemistry and petroleum	✓	✓
Stone and soil	✓	✓
Main metal	✓	✓
Metalware	✓	✓
Mining	✓	✘

"✓" indicates the existence, "✘" indicates absence of the asymmetric volatility spillover.

The length of the volatility persistence and the magnitude of the asymmetric impacts are shown in Table 8. According to the results, mean volatility persistence is approximately 4.2 days. As it is seen in the first column, the metalware sector has the longest persistence with 6.7 days, while the main metal sector has the shortest with 2.7 days. Following Yang and Doong (2004), the length of the volatility persistence is based on the half-life of a shock and defined as $ln(0.5)/ln(\gamma_{s,i})$.

In the second column of Table 8, it can be seen how differently the negative and positive innovations of oil affect the volatility of sectors. According to the results, the value is 1.0 for the mining sector and it is an expected result since the volatility spillover from oil to mining sector is not asymmetric. On the other hand, the biggest difference is calculated for main metal sector while the smallest one is for metalware sector. In other words, the negative shocks in oil affect the main metal sector approximately 1.5 times bigger than the positive shocks. The magnitude of the asymmetric impact is measured by the ratio $|-1+\theta_p|/(1+\theta_p)$ (Koutmos and Booth, 1995:751).

Table 8. Impacts of Innovations on Volatility

Sectors	Length of Persistence	Degree of Asymmetry
BİST 100 general index	5.462507	1.204138
Industry main index	3.368447	1.435081
Food and beverage	3.520371	1.347167
Textile and leather	3.557979	1.483312
Forestry and paper	3.246042	1.378031
Chemistry and petroleum	4.068461	1.212088
Stone and soil	3.330742	1.456616
Main metal	2.688961	1.497290
Metalware	6.678535	1.192369
Mining	5.777940	1.000000

The impact of a ± 1% innovation in oil on the sector returns, which defined as $\delta_p(1+\theta_p)$ for a positive 1% and $\delta_p|-1+\theta_p|$ for a negative 1% innovation (Yang and Doong, 2004:150), is shown in Table 9. For instance, a +1% (-1%) change in oil volatility increases volatility of BIST 100 general index by 0.044% (0.053%) and industry main index by 0.086% (0.124%) for the next day. Since there is no asymmetric volatility spillover from oil to the mining sector, the impact of a positive and a negative 1% change in oil volatility on the volatility of the sectors are the same ratio 0.123%.

Table 9. Impacts of Innovations in Oil on Sector Volatility

Sectors	+% 1	-% 1
BİST 100 general index	0.043925	0.052891
Industry main index	0.086133	0.123609
Food and beverage	0.067786	0.091318
Textile and leather	0.074546	0.110574
Forestry and paper	0.089145	0.122845
Chemistry and petroleum	0.046683	0.056583
Stone and soil	0.067562	0.098412
Main metal	0.088827	0.132999
Metalware	0.044334	0.052862
Mining	0.122781	0.122781

6. CONCLUSION

The asymmetric volatility spillover from oil to industrial sector and BIST100 index is investigated in this paper. Data spanning from the period between August 3rd, 2009 and June 30th, 2016, are transformed into returns series and a bivariate VAR-EGARCH model is employed to each oil and sector return pairs. In the preliminary statistics, it is observed that the data follow the similar properties as financial data and show significant ARCH effects in the residuals.

The empirical findings from related VAR-EGARCH models are presented in Table 5 and 6 and summarized in Table 7. According to the results, there is an asymmetric volatility spillover from oil returns to all of the sector returns except mining. These results are expected since oil is still the most important energy and raw material input for the industry sector. In addition, there is an asymmetric volatility spillover from oil returns to BIST 100 index as a whole. These results are consistent with the results obtained by Sattary et al. (2014) and Gencer and Demiralay (2014).

To sum up, the results show that the world oil prices are can be seen as one of the most important main determinants of the industrial sector stock prices and Borsa Istanbul as a whole. Therefore, financial investors in Turkey may follow the world oil prices in order to make accurate decisions. As an extension to this paper, it is possible to examine the asymmetric volatility spillover with different models such as GJR-GARCH model along with E-GARCH model. Thus a comparison between these exponential GARCH models can be made.

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