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The relationship between energy prices and stock prices: A MARS analysis approach*

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ABSTRACT

Energy use can determine company strategies and investor decisions at the micro level while also determining national economic policies at the macro level. The importance of energy to the world economy has led many studies in the national and international literature to investigate the relationship between energy resources and stock prices. However, these studies have reached contradictory findings regarding the existence of such a relationship. In light of the contradictions in the national and international literature, this study re-examines the relationship between energy prices and stock prices using the multivariate adaptive regression splines (MARS) method over the eight Borsa Istanbul (BIST) manufacturing industry indices (XUSIN, XMANA, XMESY, XTAST, XTEKS, XGIDA, XKAGT, and XKMYA) in the period January 2010 – December 2019. The results show that oil prices have a significant effect on all index prices; however, natural gas and electricity prices have relatively different effect levels for each index.

Enerji fiyatları ve pay fiyatları ilişkisi: MARS analizi yaklaşımı

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ÖZ

Enerji kullanımı mikro düzeyde şirket stratejilerini ve yatırımcıların kararlarını belirleyebilirken, makro düzeyde ülke ekonomi politikalarını belirleyebilmektedir. Enerjinin dünya ekonomisi için taşıdığı önem, ulusal ve uluslararası literatürdeki birçok araştırmayı enerji kaynakları ile pay fiyatları arasındaki ilişkiyi araştırmaya yöneltmiştir. Ancak, bu

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çalışmaların söz konusu ilişkinin varlığına dair çelişkili bulgular elde ettikleri gözlenmektedir. Ulusal ve uluslararası literatürdeki çelişkiler ışığında, bu çalışma enerji fiyatları ve pay fiyatları arasındaki ilişkiyi Ocak 2010-Aralık 2019 dönem aralığında BIST imalat sanayi sektörüne ait 8 endeks (XUSIN, XMANA, XMESY, XTAST, XTEKS, XGIDA, XKAGT ve XKMYA) üzerinden Çok Değişkenli Uyarlanabilir Regresyon Eğrileri (Multivariate Adaptive Regression Splines: MARS) yöntemiyle yeniden araştırmaktadır. Çalışmada elde edilen sonuçlar, tüm alt endeks fiyatları üzerinde petrol fiyatlarının önemli ölçüde etkili olduğunu; ancak doğal gaz ve elektrik fiyatlarının her bir endeks için nispeten farklı etki düzeylerine sahip olduğunu ortaya koymuştur.

Anahtar Kelimeler:
Pay fiyatları, enerji, MARS analizi.

1. Introduction

Energy has an important place in the global economy, since it shapes the competition conditions between countries and contributes to the development levels of countries (Özmerdivanlı, 2014, p. 2). Fluctuations in energy prices can affect several macro and micro indicators, such as the inflation, growth, production output, and purchasing power of the relevant country economies (Syzdykova, 2018, p. 2). Therefore, the change in energy price is a crucial indicator that should be particularly taken into account due to its possible effects on countries without an energy source.

Changes in energy prices can also have effects on the capital markets of countries importing energy. The first effect is related to the fact that an increase in energy prices can result in an increase in energy costs and current-account deficits, with a consequent decrease in national income; such increases lead to cost-based inflation due to the critical role of energy in production processes. Current-account deficits and cost inflation can in turn reduce economic growth, leading to increased rates of interest and thus affecting the capital markets indirectly. The second effect of changes in energy prices on capital markets is related to the use of energy within all sectors in an effective manner. Indeed, it has been found that even a one-unit increase in the energy price reflects adversely on the economy of an energy-importing country, decreasing the purchasing power of firms and households (Lardic and Mignon, 2006, p. 3913).

Thus, as increases in energy prices result in increased firm costs, they may lead to a decrease in the basic inputs of production, on the one hand, and cause a temporary irregularity in production function and decrease in production output, on the other (Brown and Yücel, 1999, p. 17). Additionally, increases in oil prices, transportation costs, and the price of goods and services due to increasing energy prices may pave the way toward an inflationary environment. At the same time, decreasing consumer demand for products as households seek to cut down on their expenditure in the context of weakening purchasing power negatively affects the sales of firms, leading to further reductions in firms' earnings and profit (Nguyen and Bhatti, 2012, p. 758). Eventually, firms whose net cash flows are adversely affected in this way may have to take decisions such as postponing their long-term investments and focusing on short-term strategies that aim to maintain their current status.

The importance of energy resources for both country economies and firms has been the subject of many studies in national and international literature, and this has included investigation of the relationship between energy resources and stock prices. However, in the current literature, contested findings have been observed regarding whether there is any such relationship. Some studies do indeed suggest that there is (such as Jones and Kaul, 1996; Basher and Sadorsky, 2006), while others concluded that there is not (such as Chen, Roll and Ross, 1986, Huang, Masulis and Stoll, 1996). Essentially, such controversial results may be as result of differentiation in criteria such as the energy resources, sample, sample period and frequency, and research method employed by different studies. For instance, many studies discuss only oil as a source of energy (such as Faff and Brailsford, 1999; El-Sharif, Brown, Burton, Nixon and Russell, 2005); relatively fewer studies discuss natural gas (such as Acaravcı, Öztürk and Kandir, 2012) or both energy sources (such as Boyer and Filion, 2007). Most studies relate to developed markets (such as Apergis and Miller, 2009; Filis, Degiannakis and Floros, 2011); emerging markest are included in only a limited number of studies (such as Basher and Sadorsky, 2006; Al-Fayoumi, 2009). As for sample period, most look at 10-year periods (such as Li, Zhu and Yu, 2012; Akoum, Graham, Kivihaho, Nikkinen and Omran, 2012), while daily data sets are covered in only a limited number of studies (such as El-Sharif et al., 2005; Fayyad and Daly, 2011; Abdioğlu and Değirmenci, 2014). Some studies reach their conclusions through a focus on prices (such as Jones and Kaul, 1996; Acaravcı et al., 2012) while others do so through a focus on indexes (such as Mohanty, Nandha and Bota, 2010; Arouri and Rault, 2010). Finally, most studies use vector autoregressive (VAR) tests of variance (such as Park and Ratti, 2008; Fayyad and Daly, 2011; Lee, Yang and Huang, 2012; Cunado and Gracia, 2014) and Johansen and Juselius cointegration tests (such as Adaramola, 2012; Huang, An, Gao and Huang, 2015; Syzdykova, 2017).

The contradictions found in the international literature between studies on the relationship between energy and stock prices are reflected in national literature as well. Within this context, some studies have found that the two variables are related (such as Kapusuzoğlu, 2011; Yıldırım, Bayar and Kaya, 2014; Kılıç, Bayar and Özcan, 2014; Kaya and Binici 2014) while others have found them to be unrelated (such as Aktaş and Akdağ, 2013; İşcan, 2010; Büberkökü, 2017; Karhan and Aydın, 2018). As in the international literature, most of the studies focus on oil (such as Özcan 2012; Ciner, 2013; Kisswani and Elian, 2017) or oil and natural gas (such as Boyer and Filion, 2007; Öztürk, Gümüş, Taşkın and Çağlı, 2013), with a more limited number looking at oil, natural gas, and electricity (such as Acaravcı and Reyhanoglu, 2013; Dursun and Özcan, 2019). Similar patterns to the international literature also apply regarding the utilization of stock returns (such as Gönüllü, Otluoğlu and Şengöz, 2015; Abdioğlu and Değirmenci, 2016) versus stock indexes (such as Altınbaş, Kutay and Akkaya, 2015; Kendirli and Çankaya, 2016); the acquisition of findings by means of daily (such as Güler, Tunç and Orçun, 2010; Şener, Yılancı and Tıraşoğlu, 2013; Kaya and Binici 2014) versus monthly (such as Basher, Haug and Sadorsky, 2012; Aktaş and Akdağ, 2013; Yıldırım et al., 2014) data; and the use of various methods including the Johansen and Juselius cointegration method, Granger causality (such as Güler and Nalın, 2013; Özmerdivalı, 2014; Avcı, 2015), and the VAR model (such as Berk and Aydoğan, 2012; Abdioğlu and Değirmenci, 2016).

In light of the contradictions in the national and international literature, this study aims to re-examine the relationship between the sub-index prices of the BIST manufacturing industry sector—which is highly sensitive to fluctations in energy prices due to its high level of energy consumption—and energy prices (oil, natural gas, and electricity) using the multivariate adaptive regression splines (MARS) method for the period January 2010 – December 2019. The findings reveal that the prices of oil, natural gas, and electricity have an effect on the sub-indexes of the BIST manufacturing industry sector at different significance levels.

The current study makes important contributions to both national and international literature in terms of the subject, scope, and method of the research. First of all, the fact that the current study focuses on the relationship between three different energy resources—oil, natural gas, and elecricity—and stock prices in the BIST manufacturing industry sector is important, since only a limited number of studies address the issue, especially in terms of emerging markets in the literature. Second, the study is the first to investigate the relationship between energy prices and stock prices using the MARS method. This method both establishes the effect of energy prices on stock prices and reveals the effect of the interaction of energy resources on stock prices. Finally, in the current study the relationship between energy prices and stock prices is reinvestigated using an up-to-date sample period.

This paper consists of four sections: following this introduction, the second section details the data set used to investigate the relationship between energy prices and stock prices and the MARS model employed for this purpose. The third section reports our empirical findings, and a general evaluation of the findings is made in the last section.

2. Data and methodology

2.1. Data

To investigate the effect of energy prices on the BIST manufacturing sector this study considered energy data (for oil, natural gas, and electricity) and the price data of a national index (BIST INDUSTRIALS, or XUSIN) and seven sub-indexes in the manufacturing sector: BIST food, beverage, and tobacco (XGIDA); BIST paper and paper products printing (XKAGT); BIST chemicals, petroleum rubber, and plastic products (XKMYA); BIST basic metal (XMANA); BIST fabricated metal products, machinery, electrical equıpment, and transportatıon vehicles (XMESY); BIST textıle, wearıng apparel, and leather (XTEKS); and BIST non-metallic mineral products (XTAST). In this context, the MARS model was used in order to reveal the relationship between index prices and energy prices. The sample period of the study was 4 January 2010 to 31 December 2019 and daily-frequency data was used. In the selection of the sample period, in the extant literature a preference for at least a 10-year period using daily data has proven effective. Daily stock price data for the sub-indexes and the BIST Industrial Index were collected from Borsa Istanbul Datastore, daily oil and natural gas price data from https://www.eia.gov, and electricity data from https://seffaflik.epias.com.tr.

2.2. Methodology

We set out to measure the effect of energy prices on the index prices of the manufacturing sector using the MARS 7.0 program, developed by Salford Systems. MARS analysis was developed by Jerome Friedman in 1991 and is based on a nonparametric regression equation, which ideally explains a dependant value Y of independent values X. Because it takes into account the relationship between independent variables and is not much affected by end point values, data deficiencies, and the presence of multiple connections, MARS has many advantages in comparison with other regression models (Lee and Chen, 2005, pp. 746-748).

The MARS model is an algorithmic system based on forming the maximum basis functions of all variables forward and then backward-pruning the basis functions that do not contribute to the model (Leathwick, Elith and Hastie, 2006, pp. 190–191). The next-step algorithm uses C functions instead of independent variables, unlike lineer regression models, while creating the model (Orhan, Teke and Karcı, 2018, p. 365) The MARS model formula is as follows:

$$Y_t = \beta_0 + \sum_{k=1}^{K} \alpha_k \beta_k (x_t) + \varepsilon_t \tag{1}$$

In the model:

k is the knot value

K is the number of basis functions

X is the independent variable

Ak is the kth number of basis functions

$\beta 0$ is the constant term

$\beta k\ (xt)$ is the kth basis function for the tth independent variable

In this parallel, the MARS model consists of two steps.

Step 1: All possible interactions of the variables in the model with each other constitute the basis functions. All basis functions until the model peaks are added to the model, reaching a large dimension with its most complex form. In other words, all dependent and independent variables and all combinations of these variables with each other are taken into account in the basis function (Nacar, Kangal and Hınıs, 2018).

Step 2: This is backward-pruning procedure, which means the exclusion from the model of the basis functions that make no contribution or minimum contribution to the model among the maximum basis functions reached in the first stage (Abraham and Steinberg, 2001, pp. 237–238). Through this process, which is a backward-pruning algorithm, an optimal model is established where the sum of error squares of independent variables that contribute to the model is at the lowest level. (Uzlu, 2016, p. 35). While backward-pruning, the MARS model uses the generalized cross-validation (GCV) technique (Sephton, 1994, p. 27).

The GCV technique is shown as follows;

$$GCV(M) = \frac{\frac{1}{N}\sum_{i=1}^{N}\left(y_i - \hat{f}_M(x_i)\right)^2}{\left(1-\frac{C(M)}{N}\right)^2} \tag{2}$$

$$C(M) = 1 + Cd \tag{3}$$

Here:

$\tilde{f}_m$ is the MARS estimating model

N is the number of subjects

D is the smoothing parameter

C is the complexity of the model

M is the number of functions of the model

The GCV value is a coefficient indicating the estimating error, and the lowest value of this coefficient should take part in the best model. On the other hand, another measure that should be considered is the adjusted R^2 value, which is expected to be high as a comparison measure. Thus, it is emphasized that the piecewise linear GCV and adjusted R^2 values are inversely related to each other in the best model. The knot values of the basis functions in which inverse relationship is not established are excluded from the model and the significance level of the model is addressed. The basis functions removed from the model are not re-included in the model if the significance of the model has increased and the backward-pruning stage is maintaned (Yüksel, 2016, p. 112; Oktar and Yüksel 2016, p. 38).

3. Empirical findings

Thanks to its distinctive feature of converting nonlinear data into linear form, the MARS model does not require pre-processes such as deseasonalization and making variables stationary, which are frequently used in other regression analyses. In addition, the problem of removal of certain data, which occurs in analyses with pre-processes, is eliminated. In other words, unit root tests are not needed in MARS model analyses (Yüksel, Canoz and Adalı, 2017, p. 48). The descriptive statistical results of the MARS model regarding the relationship between index prices in XUSIN and seven sub-sector indexes (XGIDA, XKAGT, XKMYA, XMANA, XMESY, XTEKS, XTAST) and energy prices for the manufacturing sector are presented in Table 1.

Table 1

MARS model dependent variables: Descriptive statistical results

	XMANA	XMESY	XTAST	XTEKS	XGIDA	XKAGT	XKMYA	XUSIN
N	2415	2415	2415	2415	2415	2415	2415	2415
Average	0.121691	95797.99	68241.94	18449.08	0.110004	40552.83	60087.71	79476.28
Medıan	0.105209	98573.74	66888.82	14938.24	0.114453	39258	45409.50	74797.39
Range	0.266423	0.147633	40621.41	39134.54	90395.67	59289.61	0.100471	0.101796
Sum	0.293884	0.231352	0.164804	0.445545	0.265659	0.979351	0.145112	0.191935
Standard deviation	69,578.37	39,217.35	9065.014	7829.23	19,646.26	8312.62	29,908.35	26,859.67
MSE	0.483915	0.153736	0.821405	0.612716	0.385816	0.690711	0.894139	0.721143
RMSE	69,563.96	39,209.23	9063.13	7827.61	19,642.19	8310.90	29,902.16	26,854.11
SSE	0.116865	0.371273	0.198369	0.147971	0.931745	0.166807	0.215935	0.174156
IMPORTANCE LEVELS								
	XMANA	***XMESY***	***XTAST***	***XTEKS***	***XGIDA***	***XKAGT***	***XKMYA***	***XUSIN***
Oil	100.00	100.00	100.00	100.0	100.00	100.00	100.00	100.00
Electricity	84.229	38.865	33.507	79.20	42.967	55.829	73.81	68.225
Natural gas	83.660	36.924	54.779	49.80	44.152	61.211	45.68	59.358

Note: MSE: Mean square error, RMSE: Root of mean square error, SSE: Sum of estimated squares.

As shown in Table 1, oil price has the greatests effect on the index prices of the manufacturing sector. The sensitivity of each index to energy prices other than that of oil varies. For example, electricity prices are more important than the prices of natural gas in relation to XMANA index prices; the significance levels are low for electricity and natural gas price effects on XMESY index prices; and finally, for XTAST index prices, the prices of natural gas are more important than the prices of electricity. It can be seen that changes in electricity prices are more significant than those in natural gas prices for the XTEKS and XKMYA indexes; the significance of changes in natural gas and electricity prices is lower that of other variables for the XGIDA index; and natural gas prices are more important than electricity prices for XKAGT index prices. On the other hand, the XUSIN index, which dominates the manufacturing sector, is more affected by changes in electricity prices than changes in natural gas prices. A summary report of the prominent data from the step-one and step-two processes of the MARS model is presented in Table 2.

Table 2

MARS model: first- and second-step algorithm results

	GCV Value	Knot Values (number of knots)	Significance	Adjusted R^2 value
XUSIN	0.231030	10	5%	0.68676
XMANA	0.168580	9	1%	0.65736
XMESY	0.423047	8	1%	0.72887
XTAST	0.485788	9	1%	0.41831
XTEKS	0.207304	9	1%	0.66723
XGIDA	0.238696	9	1%	0.39149
XKAGT	0.446135	9	1%	0.36471
KMYA	0.282017	9	1%	0.68978

Table 2 includes the knot values determined to contribute to the model as a result of the MARS model first-step algorithm, the lowest GCV values of the model, the significance levels for each index, and the adjusted R^2 value, which is the percentage of independent variables explaining the dependent variable. It can be seen that ten basis functions occurred in the results of the XUSIN MARS model and the model is significant at the 5% level. However, we also found that energy prices have the power to explain XUSIN prices at the rate of 0.68. Likewise, there are eight basis functions in the MARS model results for the XMESY index and the model is significant at the 1% level; and energy prices explain the XMESY prices at the rate of 0.72. For the other indexes in Table 2, the MARS model resulted in nine basis functions and the model established for each was significant at the 1% level. Examining the adjusted R^2 value in detail for all indexes, energy prices explain the XMANA index at the rate of 0.65, the XTEKS index at the rate of 0.66, and the XKMYA index at the rate of 0.69. On the other hand, energy prices are observed not to sufficiently explain the TAST index at the rate of 0.41, the XGIDA index at the rate of 0.39, and the KAGT index at the rate of 0.36.

Following the results of the MARS model algorithm, MARS model equations were calculated for each index of the manufacturing sector. The relevant results are reported in Tables 3–10. Table 3 refers to the MARS estimating equation results indicating the relationship between XUSIN index prices and energy prices. The equation, consisting of knot points where energy prices that contribute to the model are determined, consists of coefficients assigned to prices as four for oil, two for electricity, and four for natural gas. Examining the findings in detail, a change in electricity prices above 305.87 will have a decreased effect on the XUSIN index prices. Similarly, a positive effect (increase) was observed in XUSIN index prices if oil prices were between 62.28 and 64.35 or greater than 84.42, and a negative effect (decrease) was observed between 64.35 and 84.42; it was found that if natural gas prices are between 2.42 and 2.91 or greater than 5.51, this has a positive effect on XUSIN index prices, whereas if they are between 2.91 and 5.51 there is a negative effect.

Table 3

MARS estimation equation results for the XUSIN index/energy price relationship

Basis Funtion	Knot Values of Variable	Coefficient
BF1 =	max(0, OIL 62.28);	7026.93
BF2 =	max(0, 62.28 OIL);	-737.524
BF3 =	max(0, ELECTRICITY 305.87);	-2.68408
BF4 =	max(0, 305.87 ELECTRICITY);	-148.987
BF5 =	max(0, NATURAL GAS 2.91);	-62421.5
BF6 =	max(0, 2.91 NATURAL GAS);	20008.5
BF7 =	max(0, OIL 84.42);	2228.17
BF9 =	max(0, OIL 64.35);	-9236.39
BF11 =	max(0, NATURAL GAS 2.42);	48649.6
BF13 =	max(0, NATURAL GAS 5.51);	22504.3

Y = 102333 + 7026.93 * BF1 - 737.524 * BF2 - 2.68408 * BF3 - 148.987 * BF4 - 62421.5 * BF5 + 20008.5 * BF6 + 2228.17 * BF7 - 9236.39 * BF9 + 48649.6 * BF11 + 22504.3 * BF13;

Table 4 reports the results of the MARS estimation equation on the interaction between XMANA index prices and energy prices.

Table 4

MARS estimation equation results for the XMANA index/energy price relationship

Basis Funtion	Knot Values of Variable	Coefficient
BF1 =	max(0, OIL 64.89);	-8610.96
BF2 =	max(0, 64.89 OIL);	-1781.49
BF3 =	max(0, ELECTRICITY 280.86);	-493.356
BF5 =	max(0, NATURAL GAS 2.9);	-264598
BF6 =	max(0, 2.9 NATURAL GAS);	54847
BF7 =	max(0, NATURAL GAS 3.57);	81628.4
BF9 =	max(0, NATURAL GAS 2.42);	141544
BF11 =	max(0, ELECTRICITY 114.59);	487.146
BF13 =	max(0, OIL 60.59);	6749.52

Y = 81833.5 - 8610.96 * BF1 - 1781.49 * BF2 - 493.356 * BF3 - 264598 * BF5 + 54847 * BF6 + 81628.4 * BF7 + 171544 * BF9 + 487.146 * BF11 + 6749.52 * BF13;

Table 4 includes the coefficients of two oil, three natural gas, and two electricity basis functions and knot values of basis function 2 (TF2) and basis function 6 (TF6), which are mirror basis functions for oil and natural gas prices, in the XMANA estimation equation. Evaluating the equation results, all independent variables seem to have been significant for XMANA index prices. In this parallel, examining the independent variables' coefficients regarding the MARS model, it can be observed that the XMANA index price is positively affected if the oil price is between the values of 60.59 and 64.89; negatively affected where the oil price is above 64.89; positively affected by changes in electricity prices between 114.59 and 280.86; and negatively affected where electricity prices are above 280.86. However, it should be noted that the natural gas variable has an excessive number of break points; in more detail, the XMANA index price is positively affected in cases where natural gas prices are between 2.42 and 2.9, negatively affected where they are between 2.9 and 3.57, and positively affected where they are above 3.57.

Table 5 reports the MARS model estimated equation results measuring the response of XMESY index prices to energy prices.

Table 5

MARS estimating equation results for the XMESY index/energy price relationship

Basis Funtion	Knot Values of Variable	Coefficient
BF1 =	max(0, OIL 54.57);	593.164
BF4 =	max(0, 303.83 - ELECTRICITY);	-151.932
BF5 =	max(0, NATURAL GAS - 2.93);	-15122.6
BF6 =	max(0, 2.93 - NATURAL GAS);	-11211.2
BF7 =	max(0, OIL - 83.88);	4563.36
BF9 =	max(0, OIL - 66.33);	-4303.52
BF11 =	max(0, OIL - 102.74);	-1782.88
BF13 =	max(0, NATURAL GAS - 5.61);	28303.6

Y = 150941 + 593.164 * BF1 - 151.932 * BF4 - 15122.6 * BF5 - 11211.2 * BF6 + 4563.36 * BF7 - 4303.52 * BF9 - 1782.88 * BF11 + 28303.6 * BF13;

As shown by Table 5, there are basis functions of all energy variables in the XMESY index MARS estimating equation, but only the mirror basis function TF6 occurs for natural gas. On the basis of the coefficients, it can be observed that when electricity prices drop below 303.83 and natural gas prices are between 2.93 and 5.61, the XMESY index price is negatively affected, whereas the index price is positively affected if natural gas prices are above 5.61. Oil prices have noteworthy breaks on XMESY index prices: the XMESY index price is positively affected if oil prices are between 54.57 and 66.33, negatively affected if they are between 66.33 and 83.88, positively affected if they are between 83.88 and 102.74, and negatively affected if they are above 102.74.

Table 6 reports the results of the MARS model estimating equation results for the effect of energy prices on XTAST index prices.

Table 6

MARS estimating equation results for XTAST index/energy price relationship

Basis Funtion	Knot Values of Variable	Coefficient
BF1 =	max(0, OIL - 51.74);	-2667.93
BF2 =	max(0, 51.74 - OIL);	-271.069
BF3 =	max(0, NATURAL GAS - 2.99);	-24308.1
BF4 =	max(0, 2.99 - NATURAL GAS);	7644.86
BF5 =	max(0, OIL - 110.81);	895.678
BF7 =	max(0, NATURAL GAS - 2.34);	20346.3
BF9 =	max(0, ELECTRICITY - 310.56);	53.9103
BF11 =	max(0, ELECTRICITY - 192.47);	-52.678
BF13 =	max(0, OIL - 49.66);	2392.38

Y = 63033.3 - 2667.93 * BF1 - 271.069 * BF2 - 24308.1 * BF3 + 7644.86 * BF4 + 895.678 * BF5 + 20346.3 * BF7 + 53.9103 * BF9 - 52.678 * BF11 + 2392.38 * BF13;

According to Table 6 showing the XTAST estimation equation using the MARS model, basis function 2 and basis function 3 are the mirror basis functions of basis function 1 and basis function 4, respectively, referring to the oil and natural gas variables. Examining the equation results, XTAST index prices are expected to be positively affected in cases where electricity prices are above 192.47 and below 310.56, negatively affected where they are above 310.56, positively affected where oil prices are between 49.66and 51.74; negatively affected where they are between 51.74 and 110.81, and finally positively affected where they are above 110.81. XTAST prices are positively affected in cases where natural gas prices are between 2.34 and 2.99, and negatively affected where they are above 2.99.

The estimating equation results of the MARS model that determines the relationship between XTEKS index prices and energy prices are shown in Table 7.

Table 7

MARS estimating equation results for the XTEKS index/energy price relationship

Basis Funtion	Knot Values of Variable	Coefficient
BF1 =	max(0, ELECTRICITY - 309.7);	-76.0239
BF2 =	max(0, 309.7 - ELECTRICITY);	19.2048
BF3 =	max(0, OIL - 62.6);	2777.85
BF4 =	max(0, 62.6 - OIL);	-351.658
BF5 =	max(0, NATURAL GAS - 5.61);	4779.64
BF7 =	max(0, OIL - 84.71);	763.863
BF9 =	max(0, OIL - 64.51);	-3471.57
BF11 =	max(0, ELECTRICITY - 118.72);	75.0335
BF13 =	max(0, NATURAL GAS - 2.98);	-3095.49

Y = 17792.5 - 76.0239 * BF1 + 19.2048 * BF2 + 2777.85 * BF3 - 351.658 * BF4 + 4779.64 * BF5 + 763.863 * BF7 - 3471.57 * BF9 + 75.0335 * BF11 - 3095.49 * BF13

As shown in Table 7, basis function 2 (TF2) and basis function 4 (TF4) represent the mirror basis functions of electricity and oil prices in the XTEKS index MARS estimating equation. However, analyzing the results of the equation in detail, it can be observed that XTEKS index prices are positively affected where electricity prices take a value between 118.72 and 309.7 and oil prices take a value between 62.6 and 64.51, negatively affected where they are between 64.51 and 84.71, and positively affected where they are above 84.71. The index prices are negatively affected where natural gas prices are between 2.98 and 5.61 but positively affected where they above 5.61.

Table 8 reports the MARS model estimating equation results indicating the interaction between energy prices and XGIDA index prices.

Table 8

MARS estimating equation results for the XGIDA index/energy price relationship

Basis Funtion	Knot Values of Variable	Coefficient
BF1 =	max(0, NATURAL GAS - 2.85);	-44680.6
BF2 =	max(0, 2.85 - NATURAL GAS);	18922.8
BF4 =	max(0, 169.74 - ELECTRICITY);	-133.988
BF5 =	max(0, OIL - 79);	4397.5
BF6 =	max(0, 79 - OIL);	-316.224
BF7 =	max(0, OIL - 105.18);	-3537.67
BF9 =	max(0, OIL - 65.89);	-2939.65
BF11 =	max(0, NATURAL GAS - 2.4);	37915.1
BF13 =	max(0, OIL - 117.45);	2261.57

Y = 115073 - 44680.6 * BF1 + 18922.8 * BF2 - 133.988 * BF4 + 4397.5 * BF5 - 316.224 * BF6 - 3537.67 * BF7 - 2939.65 * BF9 + 37915.1 * BF11 + 2261.57 * BF13

Examining Table 8, it can be observed that basis function 2 (TF2) and basis function 6 (TF6) represent mirror basis functions for natural gas and oil, respectively, in the XGIDA index MARS estimating equation. Analyzing the coefficients of the independent variables in the estimating equation in detail, it can be seen that the XGIDA index is negatively affected where the electricity price is below 169.74, positively affected where natural gas prices are between 2.4 and 2.85, and negatively affected where natural gas prices are above 2.85. On the other hand, the significant number of breaks is a sign of why XGIDA index prices are more affected by oil prices. In more detail, the XGIDA index price is negatively affected if the oil price is between 65.89 and 79, positively affected where it is between 79 and 105.18, negatively affected if it is between 105.18 and 117.45, and finally, positively affected if the oil price is above 117.45.

Table 9 reports the MARS model estimating equation results indicating the interaction between energy prices and XKAGT index prices.

Table 9

MARS estimating equation results for the XKAGT index/energy price relationship

Basis Funtion	Knot Values of Variable	Coefficient
BF2 =	max(0, 303.83 - ELECTRICITY);	-31.7006
BF3 =	max(0, NATURAL GAS - 2.93);	-22968
BF4 =	max(0, 2.93 - NATURAL GAS);	3303.82
BF5 =	max(0, OIL - 56.86);	558.838
BF6 =	max(0, 56.86 - OIL);	-241.334
BF7 =	max(0, OIL - 82.08);	1520.18
BF9 =	max(0, OIL - 66.57);	-1620.42
BF11 =	max(0, OIL - 100.74);	-626.89
BF13 =	max(0, NATURAL GAS - 2.61);	19882.3
Y = 44176.8 - 31.7006 * BF2 - 22968 * BF3 + 3303.82 * BF4 + 558.838 * BF5 - 241.334 * BF6 + 1520.18 * BF7 - 1620.42 * BF9 - 626.89 * BF11 + 19882.3 * BF13;		

In the XKAGT index MARS estimating equation results shown in Table 9, it can be observed that basis function 4 and basis function 6 represent the mirror basis functions of natural gas and oil variables, respectively. Examining the coefficients of the energy variables, it can be seen that they negatively affect the XKAGT index price if electricity prices are below 303.83, positively affect the index price if natural gas prices are between 2.61 and 2.93, and negatively affect it if the natural gas price is above 2.93. On the other hand, the results show that oil prices with significant knot values of between 56.86 and 66.57 positively affect the XKAGT index price; if the knot value is between 66.57 and 82.08 this negatively affects the XKAGT index price, if it is between 82.08 and 100.74 this positively affects it, and if it is above 100.74 it again negatively affects it.

Table 10 reports the MARS model estimating equation results describing the effect of energy prices on XKMYA index prices.

Table 10

MARS estimating equation results for the XKMYA index/energy price relationship

Basis Funtion	Knot Values of Variable	Coefficient
BF1 =	max(0, OIL - 62.46);	-5451.33
BF2 =	max(0, 62.46 - OIL);	-834.194
BF3 =	max(0, ELECTRICITY - 313.7);	-209.054
BF5 =	max(0, NATURAL GAS - 5.61);	27511.9
BF6 =	max(0, 5.61 - NATURAL GAS);	-7678.53
BF7 =	max(0, OIL - 88.66);	1834.86
BF9 =	max(0, OIL - 54.73);	3688.9
BF11 =	max(0, NATURAL GAS - 2.92);	-19391.7
BF13 =	max(0, ELECTRICITY - 123.47);	205.695
Y = 83590.5 - 5451.33 * BF1 - 834.194 * BF2 - 209.054 * BF3 + 27511.9 * BF5 - 7678.53 * BF6 + 1834.86 * BF7 + 3688.9 * BF9 - 19391.7 * BF11 + 205.695 * BF13;		

As shown in Table 10, in the XKMYA index MARS model estimating equation, basis function 2 (TF2) and basis function 6 (TF6) represent the mirror basis functions of the oil and natural gas variables, respectively. Analyzing the results, it can be observed that XKMYA index prices are negatively affected if natural gas prices are between 2.92 and 5.61 and positively affected if they are above 5.61; they are positively affected if electricity prices take values between 123.47 and 313.7 and negatively affected if they are above 313.7. If oil prices are between 54.73 and 62.46 XKMYA index prices will be positively affected, if they are between 62.46 and 88.66 they will be negatively affected, and if they are above 88.66 the relevant index prices will be positively affected.

Finally, Table 11 reports the results of the ANOVA (analysis of variance) decomposition test for the relevant model within the framework of the results of the MARS model showing the relationship between energy prices and stock prices throughout the manufacturing sector.

Table 11

Relationship between manufacturing sector and energy prices: MARS model ANOVA decomposition results

	Function	**Standard deviation**	**GCV**	**Number of basis functions**	**Number of effective parameters**	**Variables**
XGIDA	1	4625.35864	0.253792	3	7.80000	NATURAL GAS
	2	4111.00684	0.252993	1	2.60000	ELECTRICITY
	3	9246.72797	0.316134	5	13.00000	OIL
XKAGT	1	1883.15228	0.473050	1	2.60000	ELECTRICITY
	2	1944.20779	0.478489	3	7.80000	NATURAL GAS
	3	3494.72004	0.532484	5	13.00000	OIL
XTEKS	1	2918.44319	0.273280	3	7.80000	ELECTRICITY
	2	3669.69478	0.312444	4	10.40000	OIL
	3	1983.88064	0.233420	2	5.20000	NATURAL GAS
XTAST	1	5089.96174	0.685013	4	10.40000	OIL
	2	2590.37887	0.545603	3	7.80000	NATURAL GAS
	3	1747.18576	0.508197	2	5.20000	ELECTRICITY
XMESY	1	24,656.98489	0.843373	4	10.40000	OIL
	2	9025.45072	0.486538	1	2.60000	ELECTRICITY
	3	8878.73102	0.480355	3	7.80000	NATURAL GAS
XMANA	1	29,503.71394	0.233717	3	7.80000	OIL
	2	24,429.64266	0.214792	2	5.20000	ELECTRICITY
	3	25,394.02064	0.214169	4	10.40000	NATURAL GAS
XKMYA	1	14,843.09066	0.448922	4	10.40000	OIL
	2	10,940.52069	0.372962	2	5.20000	ELECTRICITY
	3	7001.52489	0.316850	3	7.80000	NATURAL GAS
XUSIN	1	13,467.30289	0.361294	4	10.40000	OIL
	2	8872.12712	0.291682	2	5.20000	ELECTRICITY
	3	7809.38273	0.276948	4	10.40000	NATURAL GAS

The MARS model ANOVA test is a variance analysis for basis functions. It evaluates the effect of independent variables on the dependent variable together with the standard deviation value and GCV creteria. On the basis of the data shown in Table 11, it can be concluded that the independent variable for which standard deviation is the highest and the GCV value is the lowest among the index data is oil, and the course of oil prices has a greater impact than the other two energy prices, for natural gas and elecricity, for the manufacturing sector. In addition, it is noteworthy that the significance levels of the independent variables shown in Table 1 support the ANOVA test results.

4. Conclusion

As an indispensable part of the modern life, energy has an important role in the world economies. Use of energy in every aspect of life presents a significant cost element. Besides, it has the characteristic of raw material for some sectors. The binding effect of energy for all economies can determine company strategies and investors' decisions at the micro level, while it determines national economy policies at the macro level. A country having its own energy resources or using energy supplied from outside causes the interest on energy prices to increase. For countries that meet their needs for energy from outside their national borders, obtaining energy at minimum cost and its effective use are among the steps supporting economic development. As for countries that have their own energy resources, it is important to use energy effectively and to commercialize the surplus energy for abroad and use the resource obtained for strategies supporting economic development within the country.

The first study revealing the fact that the changes in energy prices affect the national economy was that of Hamilton (1983). His study provided a basis for many subsequent researchers (Chen et al., 1986; Kaneko and Lee, 1995; Jones and Kaul, 1996; Huang at al., 1996; Sadorsky 1999; Faff and Brailsford, 1999 etc.). Except for a few studies conducted at macro level, the literature focuses mainly on research at a micro level, and studies usually focus on the effect of energy prices on stock returns or stock prices (Ewing and Thompson, 2007; Apergis and Miller, 2009; Arouri and Rault, 2010 etc.). Some such studies have found the energy prices and stock prices are closely related (Nandha and Faff, 2008; Yıldırım et al., 2014; Kisswani and Elian, 2017 etc.), while some others have suggested that there is no relationship between the two variables (Sarı and Soytaş, 2006; Al-Fayoumi 2009; Mohanty et al., 2010 etc.). Broadly evaluating the relevant research, it can be seen that the different focuses of the extant research in terms of energy resources, countries, sample periods, and research methods can be argued as reasons for such contradictions, however, this situation seems to play an encouraging role for further studies for obtaining more clear findings.

The current study has paid regard to the deficiencies and limitations in the relevant literature, aiming to research the relationship between the energy prices and stock prices within the context of the contradictory findings. The study focused on the Turkish capital market, which has the characteristics of an emerging market, and the BIST manufacturing sector was selected, since external dependence for energy is high, and it is the sector that most needs energy. Within this context, daily data on the prices of a national index and seven sub-indexes in the manufacturing sector for the period January 2010 – December 2019 were analyzed using the MARS method for the first time.

While creating the MARS model, firstly XUSIN and then the XMANA, XMESY, XTAST, XTEKS, XGIDA, XKAGT, and XKMYA index prices were included in the analysis with energy prices, namely oil, natural gas, and electricity separately. We conclude that, according to the results obtained using the MARS model, the effectiveness of oil prices on all relevant index prices is 100%, while the natural gas and electricity prices have various levels of effectiveness on each index. On the other hand, we find that energy prices are in a significant relationship with all index prices, however, this differs by explaining index prices. Through the use of the MARS model, we conclude that energy prices sufficiently explain the XUSIN, XMANA, XMESY, XTEST, and XKMYA index prices at the rates of 68%, 66%, 73%, 66%, and 68%, respectively; however, they cannot sufficiently explain the XTAST, XGIDA, and XKAGT index prices, at the rates of 41%, 39%, and 36%, respectively.

Evaluating the study within the international literature; it has been observed that the findings of the study correspond to those of many other studies (such as Acaravcı et al., 2012; Degiannakas, 2013; Kisswani and Elian, 2017) suggesting that there is a significant relationship between energy prices and stock prices; however, they conflict with certain studies (such as Chen et al., 1986; Sayılgan and Süslü 2011; Arouri, 2011) suggesting that there is no relationship between energy prices and stock prices. In terms of national literature, the findings of the study again correspond to those of some studies (such as Yıldırım et al. 2014; Eyüpoğlu and Eyüpoğlu 2016) while conflicting with those of some others (such as Sarı and Soytaş, 2006; İşcan, 2010; Aktaş and Akdağ, 2013). From a different perspectiand, examining on the basis of energy resources, the study reandaled that there is a significant relationship between oil prices and stock prices, in line with Öztürk et al. (2013). However, different from this study, natural gas prices were found to affect the stock prices. Additionally, the study determined that there is a significant relationship between eletricity prices and stock prices, in conflict with Acaravcı and Reyhanoğlu (2013).

The scope of the findings of the study could make it an important reference for the strategic purposes to be developed by investors and company owners. Also, the findings obtained by this study that differ from the national and international literature in terms of the purpose, scope, and method to be used constitute an important basis for analyses to be made on a company basis, especially in terms of further studies addressing the relationship between energy prices and stock prices. In case of use of different types of energy in these further studies, examination of the results with various frequencies and differentiation of currencies of the variables would be important to strengthen the findings.

Author statement

Research and publication ethics statement

This study has been prepared in accordance with the ethical principles of scientific research and publication.

Approval of ethics board

Ethics committee approval is not required for this study.

Author contribution

All authors have contributed the study equally.

Conflict of interest

There is no conflict of interest arising from the study for the authors or third parties.

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References

Abdioğlu, Z. and Değirmenci, N. (2014). Petrol fiyatları-hisse senedi fiyatları ilişkisi: BIST sektörel analiz. *Kafkas Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *5*(8), 1-24.

Abdioğlu, Z. and Değirmenci, N. (2016). Petrol fiyatı şoklarının hisse senedi getirileri üzerindeki etkileri. *TISK Academy*, *11*(22), 330-351.

Abraham, A. and Steingberg, D. (2001). MARS: Still an alien planet in soft computing?, *Computational Science – ICCS 2001,* Springer-Verlag Berlin Heidelberg, New York.

Acaravcı, A., Öztürk, İ. and Kandir, Y. S. (2012). Natural gas prices and stock prices: evidence from EU-15 countries. *Economic Modelling*, *29*(5), 1646-1654. Doi: https://doi.org/10.1016/j.econmod.2012.05.006.

Acaravcı, S. and Reyhanoğlu, I. (2013). Enerji fiyatları ve hisse senedi getirileri: Türkiye ekonomisi için bir uygulama. *Nevşehir Hacı Bektaş Veli Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *3*, 94-110.

Adaramola, A. O. (2012). Oil price shocks and stock market behaviour: The Nigerian experience. *Journal of Economics*, *3*(1), 19-24. Doi: https://doi.org/10.1080/09765239.2012.11884948.

Akoum, İ., Graham, M., Kivihaho, J., Nikkinen, J. and Omran, M. (2012). Co-movement of oil and stock prices in the GCC region: A wavelet analysis. *The Quarterly Review of Economics and Finance*, *52*(4), 385-394. Doi: https://doi.org/10.1016/j.qref.2012.07.005.

Aktaş, M. and Akdağ, S. (2013). Türkiye'de ekonomik faktörlerin hisse senedi fiyatları ile ilişkilerinin araştırılması. *International Journal Social Science Research*, *2*(2), 50-67.

Al-Fayoumı, N. (2009). Oil prices and stock market returns in oil importing countries: The case of Turkey, Tunisia and Jordan. *European Journal of Economics, Finance and Administrative Sciences*, *16*, 84-98.

Altınbaş H., Kutay, N. and Akkaya, C. (2015). Makroekonomik faktörlerin hisse senedi piyasaları üzerindeki etkisi: Borsa İstanbul üzerinde bir uygulama. *Ekonomi ve Yönetim Araştırma Dergisi*, *4*(2), 30-48.

Apergis, N. and Miller, S. M. (2009). Do structural oil-market shock affect stock pices?. *Energy Economics*, *31*(4), 569-575. Doi: https://doi.org/10.1016/j.eneco.2009.03.001.

Arouri, M. (2011). Does crude oil move stock markets in Europe? A sector investigation. *Economic Modelling*, *28*(4), 1716-1725. Doi: https://doi.org/10.1016/j.econmod.2011.02.039.

Arouri, M. and Rault, C. (2010). Causal relationships between oil and stock prices: some new evidence from gulf oil-exporting countries. *International Economics*, *122*, 14-56. Doi: https://doi.org/10.1016/S2110-7017(13)60029-3.

Avcı, Ö. B. (2015). Petrol fiyatlarının hisse senedi piyasasına etkisi. *Adnan Menderes Üniversitesi, Sosyal Bilimler Enstitüsü Dergisi, 2*(3), 27-34.

Basher, S. A. and Sadorsky, P. (2006). Oil price risk and emerging stock markets. *Global Finance Journal, 17*(2), s.224-251. Doi: https://doi.org/10.1016/j.gfj.2006.04.001.

Basher, S. A., Haug, A. A. and Sadorsky, P. (2012). Oil prices, exchange rates and emerging stock markets. *Energy Economics, 34*(1), s.227-240. Doi: https://doi.org/10.1016/j.eneco.2011.10.005.

Berk, İ. and Aydoğan, B. (2012). Crude oil price shocks and stock returns: evidence from Turkish stock market under global liquidity conditions. *EWI Working Paper*, *12*(15), 1-24.

Boyer, M. and Filion, D. (2007). Common and fundamental factors in stock returns of Canadian oil and gas companies. *Energy Economics*, *29*(3), 428-453. Doi: https://doi.org/10.1016/j.eneco.2005.12.003.

Brown, S. P.A. and Yücel, M. K. (1999). Oil prices and U.S. aggregate economic activity. *Federal Reserve Bank of Dallas Economic Review*, 16–23.

Büberkökü, Ö. (2017). Çoklu yapısal kırılmalar altında petrol fiyatlarının Türk hisse senedi piyasaları üzerindeki etkisinin incelenmesi. *Bankacılık ve Sermaye Piyasası Araştırmaları Dergisi*, *1*(3), 15-32.

Chen, N., Roll, R. and Ross, S. A. (1986). Economic Forces and the Stock Market. *The Journal of Business, 59*(3). 383-403.

Ciner, C. (2013). Oil and stock returns: frequency domain evidence. *Journal of International Financial Markets. Institutions and Money, 23,* 1-11.Doi: https://doi.org/10.1016/j.intfin.2012.09.002.

Cunado, Juncal and Perez de Gracia, Fernando (2014). Oil Price Shocks and Stock Market Returns: Evidence For Some European Countries. *Energy Economics*, *42*, 365-377. Doi: https://doi.org/10.1016/j.eneco.2013.10.017.

Degiannakis, S., Filis, G. and Floros C. (2013). Oil and stock returns: evidence from Europeon industrial sector indices in a time-varying environment. *Journal of International Financial Markets, Institutions and Money*, *26*, 175-191. Doi: https://doi.org/10.1016/j.intfin.2013.05.007.

Dursun, A. and Özcan, M. (2019). Enerji fiyat değişimleri ile borsa endeksleri arasındaki ilişki: OECD ülkeleri üzerine bir uygulama. *Muhasebe ve Finansman Dergisi*, *82*, 177-198. Doi: https://doi.org/10.25095/mufad.536069.

El-Sharif, I., Brown D., Burton B., Nixon B. and Russell A. (2005). Evidence on the nature and extent of the relationship between oil prices and equity values in the UK. *Energy Economics, 27* (6), 819-830. Doi: https://doi.org/10.1016/j.eneco.2005.09.002.

Ewing, B. T. and Thompson, M. A. (2007). Dynamic cyclical comovements of oil prices with industrial production, consumer prices, unemployment, and stock prices. *Energy Policy*, *35*(11), 5535-5540. Doi: https://doi.org/10.1016/j.enpol.2007.05.018.

Eyüboğlu, K. and Eyüboğlu, S. (2016). Doğal gaz ve petrol fiyatları ile BIST sanayi sektörü endeksleri arasındaki ilişkinin incelenmesi. *Journal of Yasar University, 11*(42), 150-162. Doi: https://doi.org/10.19168/jyu.23741.

Faff, Rr W. and Brailsford, T. J. (1999). Oil price risk and the Australian stock market. *Journal of Energy Finance & Development, 4*(1), 69-87.

Fayyad, A. and Daly, K. (2011). The impact of oil price shocks on stock market returns: Comparing GCC countries with The UK and USA. *Emerging Markets Review, 12*(1), 61-78. Doi: https://doi.org/10.1016/j.ememar.2010.12.001.

Filis, G., Degiannakis S. and Floros C. (2011). Dynamic correlation between stock market and oil prices: The case of oil-importing and oil-exporting countries. *International Review of Financial Analysis, 20*(3), 152-164. Doi: https://doi.org/10.1016/j.irfa.2011.02.014.

Gönüllü, Ç., Otluoğlu, E. and Şengöz, M. (2015). Ham petrol fiyatı değişimlerinin petrokimya sektörü getirileri üzerindeki etkisi. *Uluslararası İktisadi ve İdari İncelemeler Dergisi*, *14*, 223-234. Doi: https://doi.org/10.18092/ijeas.84512.

Gupta, R. and Modise, M. P. (2013). Does the source of oil price shocks matter for South African stock returns? A structural VAR approach. *Energy Economics*, *40*, 825-831. Doi: https://doi.org/10.1016/j.eneco.2013.10.005.

Güler, S. and Nalın, H. T. (2013). Petrol fiyatlarının İMKB endeksleri üzerindeki etkisi. *Ekonomik ve Sosyal Araştırmalar Dergisi*, *9*(2), 81-98.

Güler, S., Tunç, R. and Orçun, C. (2010). Petrol fiyat riski ve hisse senedi fiyatları arasındaki ilişkinin belirlenmesi: Türkiye'de enerji sektörü üzerinde bir uygulama. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *24*(4), 297-315.

Hamilton, J. D. (1983). Oil and the macroeconomy since World War II.. *Journal of Political Economy, 91*(2): 228-248.

Huang, R. D., Masulis, R.W. and Stoll, H. R. (1996). Energy shocks and financial markets. *The Journal of Future Markets, 16,* 1-27.

Huang, S., An, H., Gao, X. and Huang, X. (2015). Identifying the multiscale impacts of crude oil price shocks on the stock market in China at the sector level. *Physica A: Statistical Mechanics and its Applications, 434,* 13-24. Doi: https://doi.org/10.1016/j.physa.2015.03.059.

İşcan, Erhan (2010). Petrol fiyatlarının hisse senedi piyasası üzerine etkisi. *Maliye Dergisi*, 158, 607-617.

Jones, C. M. and Kaul, G. (1996). Oil and the stock markets. *The Journal of Finance, 51*(2), 463-491.

Kaneko, T. and Lee, B. (1995). Relative importance of economic factors in the U.S. and Japanese stock markets. *Journal of The Japanese and International Economies*, *9*(3), 290-307.

Kapusuzoğlu, A. (2011). Relationships between oil price and stock market: an empirical analysis from Istanbul stock exchange (ISE). *International Journal of Economics and Finance*, *3*(6), 99-106. Doi:10.5539/ijef.v3n6p99

Karhan, G. and Aydın, H. İ. (2018). Petrol fiyatları, kur ve hisse senedi getirileri üzerine bir araştırma. *Akademik Araştırmalar ve Çalışmalar Dergisi*, *10*(19), 405-413. Doi: https://doi.org/10.20990/kilisiibfakademik.454782.

Kaya, A. and Binici, Ö. (2014). BIST kimya, petrol, plastik endeksi hisse senedi fiyatları ile petrol fiyatları arasındaki ilişkinin incelenmesi. *Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Dergisi*, *15*(1), 383-395.

Kendirli, S. and Çankaya, M. (2016). Ham petrol fiyatlarının BİST 100 ve ulaştırma endeksleri ile ilişkisi. *Kastamonu Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 12*, 136-141.

Kılıç, C., Bayar, Y. and Özcan, B. (2014). Petrol fiyatlarının borsa istanbul sanayi fiyat endeksi üzerindeki etkisi. *Kamu-İş, 13*(3), 125-141.

Kisswani, K. M. and Elian, M. I. (2017). Exploring the nexus between oil prices and sectoral stock prices: Nonlinear evidence from Kuwait stock exchange. *Cogent Economics & Finance*, *5*(1), 1-17. Doi: https://doi.org/10.1080/23322039.2017.1286061.

Lardic, S.and Mignon, V. (2006). The Impact of oil prices on GDP in European Countries: An Empirical investigation Based on Asymmetric Cointegration. *Energy Policy*, *34*(18), 3910-3915. Doi: https://doi.org/10.1016/j.enpol.2005.09.019.

Leathwick, J. R., Elith, J. and Hastie, T. (2006). Comparative Performance of Generalized Additive Models and Multivariate Adaptive Regression Splines for Statistical Modelling of Species Distributions. *Ecological Modelling*, *199*(2), 188-196. Doi: https://doi.org/10.1016/j.ecolmodel.2006.05.022.

Lee, B., Yang, C. and Huang, B. (2012). Oil price movements and stock markets revisited: A case of sector stock price indexes in the G-7 countries. *Energy Economics*, *34*(5), 1284-1300. Doi: https://doi.org/10.1016/j.eneco.2012.06.004.

Lee, T. and Chen I. (2005). A two-stage hybrid credit scoring model using artificial neural networks and multivariate adaptive regression splines. *Expert Systems with Applications*, *28*(4), 743-752. Doi: https://doi.org/10.1016/j.eswa.2004.12.031.

Li, S., Zhu, H. and Yu, K. (2012). Oil prices and stock market in China: a sector analysis using panel cointegration with multiple breaks. *Energy Economics*, *34*(6), 1951-1958. Doi: https://doi.org/10.1016/j.eneco.2012.08.027.

Mohanty, S., Nandha, M. and Bota, G. (2010). Oil shocks and stock returns: the case of the Central and Eastern European CEE oil and gas sectors. *Emerging Markets Review*, *11*(4), 358-372. Doi: https://doi.org/10.1016/j.ememar.2010.06.002.

Nacar s., Kangal M. and Hınıs A. (2018). Çok değişkenli uyarlanabilir regresyon eğrileri (ÇDURE) ile günlük akarsu akımlarının tahmini-haldizen deresi örneği. *GUFBED*, *8*(1), 38-47. DOI: 10.17714/gumusfenbil.311188.

Nandha, M. and Faff, R. (2008). Does Oil Move Equity Prices? A Global View. *Energy Economics*, *30*(3), 986-997. Doi: https://doi.org/10.1016/j.eneco.2007.09.003.

Nguyen, C. and Bhatti, M. (2012). Copula model dependency between oil prices and stock markets: Evidence from China and Vietnam. *Journal of International Financial Markets, Institutions and Money, 22*(4), 758-773. Doi: https://doi.org/10.1016/j.intfin.2012.03.004.

Oktar, S. and Yüksel, S. (2016). Bankaların türev ürün kullanımını etkileyen faktörler: MARS yöntemi ile bir inceleme. *Finans Politik & Ekonomik Yorumlar, 53*(620), 31-46.

Orhan, H., Teke, E.C. and Karcı Z. (2018). Laktasyon eğrileri modellenmesinde çok değişkenli uyarlanabilir regresyon eğrileri MARS yönteminin uygulanması. *KSÜ Tarım ve Doğa Dergisi, 21*(3), 363-373. Doi:10.18016/ ksudobil.334237.

Öztürk, M. B., Gümüş, G., Taşkın F.D. and Çağlı, E. (2013). Petrol ve doğalgaz fiyatları ile imalatve kimya-petrol-plastik sektörlerinin endeksleri arasındaki ilişki. *Niğde Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 6*(2), 64-74.

Park, J. and Ratti, R. A. (2008). Oil Price Shocks and Stock Markets in The U.S. and 13 European Countries, *Energy Economics,* 30(5), 2587-2608. Doi: https://doi.org/10.1016/j.eneco.2008.04.003.

Sadorsky, P. (1999). Oil Price Shocks and Stock Market Activity. *Energy Economics, 21*,449-469.

Sarı, R. and Soytaş, U. (2006). The relationship between stock returns, crude oil prices, ınterest rates, and output: evidence from a developing economy. *The Empirical Economics Letters, 5*(4), 205-220.

Sayılgan, G. and Süslü, C. (2011). Makroekonomik Faktörlerin Hisse Senedi Getirilerine Etkisi: Türkiye ve Gelişmekte Olan Piyasalar Üzerine Bir İnceleme. *BDDK Bankacılık ve Finansal Piyasalar, 5*(1), 73-96.

Sephton, P. S. (1994). Cointegration Tests on MARS. *Computational Economics, 7*, 23-35.

Syzdykova, A. (2017). The effect of oil prices on stock markets: The case of Kazakhstan stock exchange., *Research of Financial Economic and Social Studies, 2*(4), 259 –269.

Syzdykova, A. (2018). The impact of oil prices on BRIC countries' stock markets. *International Journal of Economics, Business and Politics, 2*(1), 1-20.

Şener, S., Yılancı, V. And Tıraşoğlu, M. (2013). Petrol fiyatları ile borsa İstanbul'un kapanış fiyatları arasındaki saklı ilişkinin analizi. *Sosyal Ekonomik Araştırmalar Dergisi 26*,231-248.

Uzlu, E. (2016). *Kıyıya dik katı madde hareketi sonucu oluşan yığılma profilinin fiziksel modelle incelenmes*i, (Yayımlanmamış Doktora Tezi). Karadeniz Teknik Üniversitesi Fen Bilimleri Enstitüsü, Trabzon.

Ünlü, U. and Topçu, M. (2012). Petrol fiyatları hisse senedi piyasalarını doğrudan etkiler mi: İMKB örneği. *İktisat İşletme ve Finans, 27*(319), 75-88. Doi: 10.3848/iif.2012.319.3438

Yıldırım, M., Bayar, Y. and Kaya, A. (2014). Enerji fiyatlarının sanayi sektörü hisse senedi fiyatları üzerindeki etkisi: Borsa İstanbul sanayi sektörü şirketleri. *Muhasebe ve Finansman Dergisi.* (62),93-108.

Yüksel, S. (2016). Türkiye'de cari işlemler açığının belirleyicileri: MARS yöntemi ile bir inceleme. *Türkiye Bankalar Birliği Bankacılar Degisi, 27*(96), 102-121.

Yüksel, S., Canoz, İ. and Adalı, Z. (2017). Türkiye'deki mevduat bankalarının fiyat-kazanç oranını etkileyen değişkenlerin MARS yöntemi ile belirlenmesi. *Fiscaoeconomia, 1*(3), 40-55.