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## PRICE TRANSMISSION BETWEEN GOLD, SILVER, COPPER PRICES AND MINING INDEX IN TURKEY

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Mustafa Uysal<sup>1</sup>,

Tuğba Kayhan<sup>2,3</sup>

### Abstract

Mining industry has a substantial role for countries development and economies. A fluctuation in the prices of precious metals affects the mining sector companies. The determination of this relationship is important for the development of countries. In order to fill in this gap, we studied on the relation between gold, silver, copper prices and Mining Index (XMADN) in Borsa İstanbul Stock Exchange (BIST). 1477 daily observations for the time period between 4 February 2013 to 13 December 2018 were used. To detect the cointegration between gold, silver, copper and Mining Index, we use Fourier Autoregressive Distributive Lag FADL which was developed by Banerje et al (2017). We find no evidence of a long run relation but strong significant feedback in the short run. Gold and copper price have positive relation with mining index. On the other hand, silver price has negative relation with mining index. This study provides practical implication to investors, portfolio managers, policy makers and academicians in terms of portfolio diversifications and risk management.

**Keywords:** *Fourier Autoregressive Distributive Lag Method, Metal Prices, Mining Index*

**JEL:** *G1, G10, G13*

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## ALTIN, GÜMÜŞ, BAKIR FİYATLARININ BORSA İSTANBUL MADENCİLİK ENDEKSİ İLE OLAN FİYAT İLİŞKİSİ

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### Öz

Günümüzde, madencilik sektörü, ülkelerin kalkınması ve ekonomileri için önemli bir rol oynamaktadır. Kıymetli madenlerin fiyatlarında meydana gelecek bir dalgalanma madencilik sektörü şirketlerini etkiler. Bu ilişkinin tespiti ülkelerin kalkınması için önem arz etmektedir. Bu amaçla altın, gümüş ve bakır fiyatları ile Borsa İstanbul (BİST) ulusal pazarda işlem gören Madencilik Endeksi (XMADN) arasındaki ilişki incelenmiştir. 4 Şubat 2013 - 13 Aralık 2018 arasındaki dönem için 1477 günlük gözlem kullanılmıştır. Altın, gümüş ve bakır fiyatları ile Madencilik Endeksi (XMADN) arasındaki uzun dönem ilişki Banerje vd. (2017) tarafından geliştirilen Fourier Otoregressive Dağıtıcı Lag (FADL) eşbütünleşme testi kullanılarak analiz edilmiştir. Elde edilen sonuçlara göre, ele alınan değişkenler arasında uzun dönemde bir ilişki tespit edilememiş ancak kısa dönemde madencilik endeksi ile altın ve bakır fiyatları arasında istatistiksel olarak anlamlı ve pozitif, gümüş fiyatları ile ise istatistiksel olarak anlamlı ve negatif bir ilişki tespit edilmiştir. Bu çalışma yatırımcılara, portföy yöneticilerine, politika yapıcılara ve akademisyenlere portföy çeşitlendirmeleri ve risk yönetimi açısından pratik bir uygulama sunmaktadır.

**Anahtar Kelimeler:** *Fourier Otoregressive Dağıtıcı Lag Yöntemi, Metal Fiyatları, Madencilik Endeksi*

**JEL:** *G1, G10, G13*

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<sup>1</sup> Assist. Prof. Dr., Artvin Coruh University, UBYO, Department of Banking and Finance, muysal@artvin.edu.tr, ORCID: 0000-0002-6377-2644

<sup>2</sup> Ph.D (c) (All but Dissertation) and Research Assistant, Yeditepe University, Faculty of Commerce, Department of Management Information Systems, tugba.erdogan@yeditepe.edu.tr, ORCID: 0000-0002-6347-6298

<sup>3</sup> Corresponding Author

## 1. Introduction

Mining industry plays a substantial role of developing countries wherefore mining industry provides energy sources to developing countries to increase production. Increasing productions depend on energy and energy resources. Countries which has insufficient energy and energy resources have to import energy from other countries. This trade situation causes foreign exchange loss in terms of developing countries, Condur and Evlimoglu (2007:26). Furthermore, mining sector is sensitive to the fluctuations in hard commodity prices due to the fact that its fixed expenses are high and requires intensive capital, Eyüboğlu and Eyüboğlu (2016: 2). In order to ban foreign exchange loss and current deficit, developing countries should attach more importance energy resources and mining sectors than development countries.

On the other hand, although precious metals are mines, they are not used in energy production. They are used for a different purpose such as investment tool. Over and above, precious metals play an important role for portfolio diversification and use the portfolio hedging tools Hillier et al. (2006:104). Portfolio managers, investors, policy makers want to minimize of risk and maximize of return for their investments. While doing this, they can use precious metals such as gold, silver, palladium and copper. To ensure returns against risk of high volatile market behaviors, they need to get right instrument for hedging.

Despite, there are lots of studies for this phenomena in literature; our study differs from literature; because it is the first study about determination of the relationship between precious metals gold, silver, palladium, copper and mining index XMADN in Istanbul Stock Exchange. Furthermore, this study is the first one to determine the relationship between precious metals and mining index by using novel approach Fourier Autoregressive Distributive Lag FADL cointegration test which is proposed by Banerjee et al. (2017) was used.

The next section of this paper includes a review of the brief literature with respect to domestic and foreign researches. Before modelling, a sample data description is presented, then we propose a novel model to detect the relationship between metal prices (gold, silver and copper) and mining index. It is also a model that clearly defines the effect of gold, silver and copper prices on the return of the index of mining stocks. Moreover, this model shows that the sensitivity of the value of the mining index with respect to the price of gold, silver and copper depends upon the long and short term relationship. Next, empirical tests of the model are managed and then results are summarized. In the last section conclusion is detailed.

## 2. Literature

Many studies have been conducted in the literature to investigate the effects of metal, precious metal and commodity prices on stocks prices.

Tuna (2019:110) investigated the relationship between precious metals and developing, developed Islamic stock markets. She used gold, silver, platinum, palladium as precious metals and including 21 developed, 11 developing countries Morgan Stanley Capital Index as Islamic stock index. She found that gold, silver, platinum and palladium can be used effectively in portfolio diversification for developed Islamic stock market. In addition, only gold and palladium can be used in portfolio diversification for developing Islamic stock market.

Celik et al. (2018:218) explored the return and volatility relation between emerging markets and precious metals. To determine the relationship, they used the multivariate VAR-EGARCH analysis. To end up, they found that negative information shocks are more dominant on precious metals than positive information shocks. The relationship between return of Gold and equity of Indonesia, India, Brazil and Turkey have positive spillover. On the other hand, the relationship between return of brent petrol and equity of Indian, Brazil, Turkey have negative spillover. South Africa market is the only market that has positive spillovers on precious metals.

Ağazade (2018:123) employs monthly data for 1995-2017 to examine the relationship between real oil prices and real exchange rate of Azerbaijan, an oil exporting country. In addition to detect the relationship, a linear cointegration test and a threshold autoregressive (TAR) method and a momentum threshold autoregressive (MTAR) method were used. Study findings support the existence of cointegration relationship between real exchange rate and real oil prices for Azerbaijan.

Metadger and Boulila (2018:295) aimed to emphasize the impact of the commodity market and the precious metals on Islamic stock market by using causal relationship analyses for Asia Pasific countries. They found that sukuk and commodity market prices were in interaction but oil was not in interaction with precious metals.

Ameer et al. (2018:358) studied on the relationship between Frankfurt stock exchange and gold prices between years 2004 and 2016. Researchers detected positive correlation between Frankfurt stock exchange and gold prices for pre-crisis period, weak positive and insignificant relationship for during crisis period and high negative correlation for after crisis period.

Yılancı (2017:61) study tested the long run relationship between oil prices and economic growth using monthly data. He used Fourier stationary test which is stationary at first differences and Fourier cointegration test to detect the relationship. He found that there is no long run relation between oil prices and economic growth.

Gopal and Munusamy (2016:46) determined the relationship between gold, crude oil, US dollar rates and Standard and Poors BSE100 in India. Impact of long run shock in Standard and Poors BSE100 caused to increase US dollar exchange rate and oil prices.

Ewing and Malik (2016:12) seek for the volatility of oil prices and United States stock market prices with structural breaks using daily data from 1996 to 2013. Significant direct and indirect spillover of volatility between oil and the stock market were found by using structural breaks.

Eyüboğlu and Eyüboğlu (2016:159) explored the relationship between natural gas & oil prices and Istanbul stock Exchange industrial index. They studied the time period of 2005-2015. Findings showed that there is a long-term relationship between both natural gas and oil prices and the current index.

Dogru and Uysal (2015:252) investigated the relationship between gold prices and Istanbul stock exchange BIST100. Researchers carried out this study in two stage such as before and after global crisis period. They emphasized that there is strong correlation between gold prices and stock market. In addition, they added about relationship which there is positive significant correlation before global crisis but there is negative significant correlation after global crisis period.

Ferraro et al. (2015:137) investigated the relationship between exchange rate and oil prices using daily data. They tried to forecast the exchange rate via oil price fluctuation. They discovered short-run relation the fluctuation in the price of a country which is major commodity export and fluctuation in its nominal rate.

Akgul et al. (2015:409) studied on gold prices and stock price index nonlinear linkages using Markov-Switching Bayesian VAR models. They found that Standard and Poor index gives different response gold prices for all crisis stages.

Gencer and Kılıç (2014:171) explored interaction between gold, oil and Istanbul stock exchange sector returns. They found negative correlation between gold prices and holding, mainmetals, commercial industrials. Oil GARCH and golds GARCH effects on portfolio volatility are significant and close to unity for each models.

Gencer and Musoğlu (2014:706) carried out a study about volatility transmission between gold, bonds and Istanbul Stock Exchange. They found that bi-directional relation between gold and Istanbul stock markets for the time period between 2006 and 2013.

Asteriou et al. (2013:117) studied the effect of oil price fluctuations on the stock markets and the interest rates in oil importing and oil exporting countries. Relation between the oil prices and the stock markets is stronger than with the interest rates in the short and in the long-run. Moreover, the effect on oil importing countries is more significant than on oil exporting countries. Furthermore, there is different impact of oil price volatility on developing and developed countries.

Mohanty et al. (2011:54) searched developing countries in Gulf Cooperation Council unlike many studies which are examined developed economies. They investigated the relation between movements in crude oil prices and equity returns using the time period between June 2005 and December 2009. They reached that changes of oil prices effect significantly GCC countries economies and stock returns.

Narayan and Sharma (2011:3262) investigated the relationship between oil price and firm returns using 560 companies listed on the New York Stocks Exchange. They found that oil price influences return of firms in terms of industrial location, lagged effect and is concluded that oil price is depended on different regimes.

Arouri et al. (2011:1393) investigated the volatility transmission between oil and stock markets in Europe and the United States from an industrial perspective. They wondered deeply that the DJ Stoxx Europe 600 and S&P 500 may camouflage the sector specific characteristics. Moreover, the oil shock can also react differently to sectors. Sample data is composed of several sectors in Europe and the United States. In addition, the Dow Jones (DJ) Stoxx Europe 600 index and the S&P 500 index are compared with respect to empirical outputs across industrials and market levels. They find significant volatility transmission in oil and stock market industrials. Furthermore, the transmission of volatility is conspicuously clear from oil to stocks than from stocks to oil for Europe.

Soytas and Oran (2011:359) examines the causality relationship between world spot oil market returns and Istanbul Stock Exchange 100 index returns, ISE electricity index returns using daily data for the time period from 2003 to 2007. They found that changes in oil prices have no effect on financial sector returns in Turkey.

Masih et al. (2011:981) explored that the relationship between the oil price volatility and stock price in Korea which is an emerging market. The results show the volatility in oil prices provide an advantage on real stock returns.

Sari et al. (2010:362) examines the relationships between the US dollar/euro exchange rate and spot prices of precious metals (gold, silver, platinum, and palladium), oil. They find that weak long-run relationships between the US dollar/euro exchange rate and spot prices of precious metals, oil.

Apergis and Miller (2009:574) examined how structural shocks characterizing the endogenous character of oil prices affect the returns of the countries. They reached that there is no relation between the international stock market returns and oil market shocks.

Sadorsky (2008:3861) takes another new evidence of a relationship between oil price behaviours and stock prices with respect to firm size using 500 large firms, 400 medium-sized firms, 600 small firms between the time period 1990 and 2006. Evidence shows that medium-sized firms have strong relation between oil price and stock price. heter

Sarı and Soytaş (2006:205) analysed the impact of oil price shocks on Turkey which can be considered as an emerging country. Their outcomes show that oil price changes are substantial factors in real stock returns, inflation, employment and GDP. In addition, they found that oil price shocks do not have a significant effect over inflation adjusted stock returns in Istanbul Stock Exchange.

Hillier et al. (2006:104) aimed do precious metals such as gold, platinum and silver use as hedging instrument for portfolio using the period between 1976 and 2004 daily US data. They

found that these metals have low significant correlation between stock returns and can be used hedge instrument during abnormal stock market volatility behavior.

Sadorsky (2001:17) studied uses a model to predict the expected returns of Toronto stock Exchange oil and gas sector stock prices using monthly data with time period from 1983 to 1999. Outcomes are shown that exchange rates, crude oil prices and interest rates have significant effect on stock price returns in the Canadian oil and gas sector.

Citak (1999:52) researched the world gold market, Istanbul gold exchange and gold based risk management in his study. Researcher claims that gold has negative or zero correlation between stocks and bonds or bills markets. This means gold can be used as hedge instrument for stock and bonds, bills markets.

Tufano (1998:1050) research examines how gold mining firms in North America are subject to changes in gold prices between the period January 1990 to March 1994. The average mining stock is 2 percent for each 1 percent change in gold prices. In addition, gold firms have significantly negative relation with gold prices.

Blose and Shieh (1995:136) studied on 23 publicly traded gold mining firms using monthly data between year 1981 and 1990. They found that the value of the gold mine is a function of the return on gold, the production costs, the level of gold reserves and the ratio of assets that are not related to the price of gold.

As we look at the literature briefly, we see that there is a transmitted relationship between metal prices (Gold, Silver, Copper) and stock prices or stock indexes. In the light of the information which was provided by the literature, we examine the relationship between gold, silver, copper metal prices and the mining index.

### **3. Data**

In this study, we investigated relation between gold, silver and copper prices and mining index (XMADN) in Borsa Istanbul Stock Exchange, Turkey. Data are daily indices for XMADN industrials in Borsa Istanbul stock market and gold, silver, copper prices from 4 February 2013 to 13 December 2018. Data start on 4 February 2013 because the XMADN index is started to be calculated by Borsa Istanbul Stock Exchange and became effective in Turkey from that day. There are 1477 daily observations and all data is USD denominated. All data are provided by Financial Information News Network FINNET. In order to eliminate possible heteroscedasticity problem, we applied of natural logarithm for all variables.

### **4. Methodology**

At this study, we investigated the long-term relationship between metal prices and mining index XMADN. Before investigation, we checked that all series are stationary or not. In order to determine the stationary level of all series, we applied standart Augmented Dickey-Fuller test (1981) (ADF) and Fourier Augmented Dickey-Fuller (ADF) test which is developed by Christopoulos and León-Ledesma (2010). After we got stationary series, we explored to detect possible cointegration between series. While we are analyzing cointegration between all series, we use the novel approach of Fourier ADL (Autoregressive Distributive Lag) cointegration test which is developed by Banerjee et al. (2017). In the study, the causality relationship between the series was investigated by Granger causality test based on Vector Autoregressive (VAR) model.

Fourier unit root test which is proposed by Christopoulos and León-Ledesma (2010) (CL) eliminates some problems such as period, type, or number of structural breaks. The number of unknowns and types of structural breaks are estimated Yilanci et al. (2014). The fact that structural breaks are not identified as a priori have been the most important advantage of this test against other break tests. Trigonometric expressions were added to CL Fourier unit root test in order to

reveal the large changes in the deterministic components of variables. CL fourier unit root test for improved regression equations are as follows: Christopoulos ve León-Ledesma (2010).

$$y_t = \omega_0 + \omega_1 \sin\left(\frac{2\pi kt}{T}\right) + \omega_2 \cos\left(\frac{2\pi kt}{2}\right) + v_t \quad (1)$$

where t is trend term, T is population size,  $\pi = 3.1416$ , k is proper frequency. In order to determine proper frequency, k is given value between 1 and 5. Afterwards, k is then selected as the optimal frequency ( $\hat{k}$ ) in the model that makes the sum of the residual squares (SSR) minimum. The null hypothesis of the unit root test is shown as follows:

$$H_0: v_t = \mu_t, \mu_t = \mu_{t-1} + h_t$$

Here,  $h_t$  is assumed to be a stationary process where mean is zero. Once the optimal frequency is selected, the least squares OLS residuals are obtained using equation number (2)

$$\hat{v}_t = y_t + \left[ \hat{\omega}_0 + \hat{\omega}_1 \sin\left(\frac{2\pi \hat{k}t}{T}\right) \right] + \hat{\omega}_2 \cos\left(\frac{2\pi \hat{k}t}{T}\right) \quad (2)$$

The OLS residuals from the 2nd equation is used for unit root test using equation number (3) below.

$$\Delta v_t = a_1 v_{t-1} + \sum_{j=1}^p \beta_j \Delta v_{t-j} + u_t \quad (3)$$

In equation 3,  $u_t$  refers to the white noise error term. This method allows the unit root tests to be performed after the breakages in the deterministic components have been cleared. Equation 3 is expressed as Fourier ADF. The t-statistics obtained at the end of the analysis are tested against the critical values of Christopoulos and León-Ledesma (2010), and the null hypothesis (where the series is not stationary) is tested against  $H_1: \alpha_1 \neq 0$  (where the series is stationary)  $H_0: \alpha_1 = 0$ . The significance of the trigonometric variables ( $H_0: \omega_1 = \omega_2 = 0$  against the alternative  $H_1: \omega_1 = \omega_2 \neq 0$ ) will be evaluated using the F test. The rejection of the null hypothesis indicates that the variable is stable around the deterministic trend of the break. F statistic values Backer et al. (2006) will be compared with the critical values prepared. Backer et al. (2006) stated that one or two frequencies would be sufficient to detect significant breaks in the data, but the detection power would decrease if more than two frequencies were used Yılançı ve Eriş (2013).

In order to examine the possible long-term relationship between the series, Banerjee et al. (2017) Fourier ADL Cointegration Test was used. ADL approach to the cointegration approach was first identified by Banerje et al. (1998). However, in 2017 Banerjee et al. developed a new cointegration test involving the fourier function in the deterministic term, which takes into account the unknown forms of nonlinear fractures based on ADL. The resulting model is called FADL and is shown as the following equation; Banerjee et al. (2017):

$$\Delta y_{1t} = d(t) + \delta_1 y_{1,t-1} + \gamma' y_{2,t-1} + \varphi' \Delta y_{2t} + \epsilon_t \quad (4)$$

In equation 4,  $\gamma'$ ,  $\varphi'$  ve  $y_{2t}$ ,  $n \times 1$  denote vectors of parameter and explanatory variables,  $d(t)$  is the deterministic term  $d(t)$  and the  $y_{1t}$  is the dependent variable. The error term ( $\epsilon_t$ ) lagged values of the variables difference which are put on the right side of the equation may be added to control the possible serial correlation. The deterministic term  $d(t)$  in the equation can be defined as follows:

$$d(t) = \gamma_0 + \sum_{k=1}^q \gamma_{1,k} \sin\left(\frac{2\pi kt}{T}\right) + \sum_{k=1}^q \gamma_{2,k} \cos\left(\frac{2\pi kt}{2}\right) \quad q \leq T/2 \quad (5)$$

In the equation 5, the usual deterministic trend containing constant and linear trend in  $\gamma_0$  denotes the single frequency component, the frequency of  $q$ , the number of  $T$  observations. The result of the test was obtained from Banerjee et al. (2017) compared with their critical values; the null hypothesis ( $H_0 : \delta_1=0$ ) is tested against the alternative hypothesis ( $H_1 : \delta_1 <0$ ). The null hypothesis is that the series are not cointegrated, whereas the alternative hypothesis is that the series are cointegrated.

The linear causality relationship between two series,  $X_t$  and  $Y_t$ , is analyzed in the following VAR model:

$$Y_t = \gamma_0 + \sum_{i=1}^p \gamma_{1i} Y_{t-i} + \sum_{i=1}^p \gamma_{2i} X_{t-i} + \varepsilon_{1t} \quad (6)$$

$$X_t = \omega_0 + \sum_{i=1}^p \omega_{1i} Y_{t-i} + \sum_{i=1}^p \omega_{2i} X_{t-i} + \varepsilon_{2t} \quad (7)$$

In equations 5 and 6,  $p$  indicates the delay length,  $\gamma$  and  $\omega$  are the parameters to be estimated and  $\varepsilon_t$  is the error term with white noise characteristics. The null hypothesis that there is no Granger causality relationship from  $X_t$  series to  $Y_t$  series is established as  $H_0 : \gamma_{2i} = 0$ . Applying Wald (F-test), The alternative hypothesis is that there is Granger causality from the  $X_t$  series to the  $Y_t$  series is established as  $H_1 : \gamma_{2i} \neq 0$ .

## 5. Results

Descriptive statistics of the variables are shown in Table 1. According to Table 1, the highest volatility is found in mining index and gold.

Table 1: Descriptive Statistics

	LGOLD	LSILVER	LCOPPER	LMINING
Mean	6.070	2.871	1.020	9.401
Median	6.059	2.833	1.041	9.452
Maximum	6.857	3.460	1.324	10.539
Minimum	5.157	2.615	0.662	8.252
St. Deviation	0.340	0.157	0.155	0.484
Skewness	-0.053	1.127	-0.528	0.199
Kurtosis	2.817	4.569	2.202	2.545
Observations	1.477	1.477	1477	1.477

Stationary levels of the variables are examined by ADF and Fourier ADF (FADF) unit root tests, respectively. The results are presented in Table 2 and Table 3. Table 2 presents the ADF unit root test results for the variables.

Gold and mining shares are seen by investors as an investment tool, while silver and copper are considered as investment instruments at a relatively low level. Therefore, gold and mining shares are more exposed to speculative movements than silver and copper. Speculative movements are more likely to expose their volatility.

When the descriptive statistics are examined, the standard deviations of gold and mining index are higher than those of silver and copper, while their yields are higher. This situation is suitable with basic relation of risk and return in finance literature.

According to the standard ADF unit root test, which does not take into account the structural breaks as presented in Table 2, it is seen that all the variables are stationary when their first differences are taken. Namely, it is seen to become  $I(1)$ . According to the standard ADF unit root test, which does not take into account the structural breaks as presented in Table 2, it is seen that all the variables are stationary when they are  $I(1)$ . The t-statistic method was used to determine the optimal lag length.

Table 2: ADF unit root test results

Variables	I (0)		I (1)	
	Constant	Constant and Trend	Constant	Constant and Trend
LGOLD	-1.27 (17)	-2.91 (16)	-9.12* (16)	-9.13* (16)
LSILVER	-3.18** (18)	-3.25 (18)	-10.11* (17)	-10.18* (17)
LCOPPER	-1.85 (16)	-1.56 (16)	-10.83* (15)	-10.90* (15)
LMINING	-2.43 (22)	-2.08 (22)	-6.66* (21)	-6.80* (21)

**Note:** \*, \*\*, \*\*\* is the significance level %1, %5 ve %10, respectively. The values in parentheses indicate the optimal lag length.

After the standard ADF test, FADF test was applied to the series considering the structural breaks and the results are presented in Table 3. In Table 3, it is seen that the first differences of all series are stationary. To test the significance of trigonometric terms, the series F test was applied. Since the obtained F-statistic values of the series which were stationary were smaller than the critical values, the trigonometric terms of all series were meaningless. Therefore, standard ADF unit root test results will be used in the next analysis.

Table 3: FADF unit root test results

Variables	Frequency ( $\hat{k}$ )	Min SSR	FADF	F-statistic F(k)
LGOLD	1	103.851	-1.273 (17)	479.440
LSILVER	2	27.109	-3.435** (18)	257.399
LCOPPER	1	9.719	-2.165 (16)	1.958.389
LMINING	1	103.256	-3.499*** (22)	1.732.998
$\Delta$ LGOLD	4	0.314	-9.394* (16)	2.183
$\Delta$ LSILVER	1	0.329	-10.262* (17)	1.294
$\Delta$ LCOPPER	2	0.229	-9.168* (22)	1.730
$\Delta$ LMINING	1	1.641	-6.814* (21)	1.622

**Note:** \*, \*\*, \*\*\* is significance level at %1, %5 ve %10, respectively. The values in brackets refer to the optimal lag length. FADF values for the critical values (k=1) için %10, %5, %1 are -3.46, -3.78 and -4.40, respectively. F test critical values used to test the significance of trigonometric terms are 3.935, 4.651 and 6.281 at level %10, %5 ve %1, respectively.

Banerjee cointegration test was used to determine whether there is a long-term relationship between the metal prices determined to be stable and the mining index.

Table 4: Banerjee Cointegration test Results

Frequency	Min SSR	Banerjee Cointegration test Statistics	Independent Variables	Lag of Independent Variables
1	-3.974	-3.089	LGOLD	1
			LSILVER	1
			LCOPPER	3

**Note:** Critical values for the Banerjee cointegration test are -4.14, -4.45 and -5.02 at level 10%, 5% and 1% respectively.

Table 4 shows the results of the Banerjee cointegration test. As the test statistics obtained according to the Banerjee cointegration results in Table 4 are smaller than the critical values, the null hypothesis that there is no long-term relationship between the metal prices and the mining index could not be rejected. The short term relationship between the metal prices and the mining index, which cannot be obtained in the long term relationship, has been examined with the standard OLS method and the results are shown in Table 4.

Table 5: Mining Index Estimation Results

Variables	Coefficients	t-statistic	Probability
$\Delta$ LMINING			
Constant	0.0002	0.3593	0.719*
$\Delta$ LGOLD	1.1478	16.1821	0.000**
$\Delta$ LSILVER	-0.4192	-5.7219	0.000**
$\Delta$ LCOPPER	0.2974	4.3669	0.000**
R <sup>2</sup>	0.18		

**Note:** \*, \*\*, \*\*\* is denoted significance level at %1, %5 ve %10.  $\Delta$  refers to the first difference of series.

According to Table 5, it was determined that the relationship between silver prices and mining index is statistically significant and negative. Gold and copper prices have a statistically significant but positive effect on the mining index in contrast to silver prices. In this study, R<sup>2</sup> value is 0.18. Literature such as (Tufano, 1998:1035; Zhang and Wei 2010:173; Blose and Shieh 1995:134) also found that R<sup>2</sup> value is low in their studies. R<sup>2</sup>'s low output indicates that a small portion of the changes in the mining index is explained by changes in gold, copper and silver prices. This is maybe due to the fact that the mining index is affected by both global and local changes, while gold, copper and silver prices are only affected by global supply and demand changes. In other words when we analyze the data period of 2013-2018 we see that this period abundant in terms of volatility increasing local events in Turkey (such as "Gezi Events"). In fact, when we look at the CDS rates, exchange rates and interest rates of Turkey during the period 2013-2018, we see an almost gradual increase meaning that local events have differentiated Turkey from global markets in a negative way. In order to increase the explaining power of the equation, variables that will capture the effect of local developments can be added to the equation such as BIST100 index. However, the main aim of the article is not to increase the R<sup>2</sup> of the equation but to understand the effect of gold, silver and copper prices on the mining index.

The increase in gold prices increases the profitability of mining companies because most of the companies in the mining index of our country extract and operate gold mine. Therefore, the value of the shares in the short term increases with the increase in gold prices. As a matter of fact, this situation was confirmed as expected with the positive and meaningful coefficient of the coefficient of gold in the regression analysis.

In addition, LM test was performed to determine if the model had autocorrelation of residuals. According to the results in Table 6, there is no autocorrelation problem in the model.

Table 6: Autocorrelation LM Test

Lags	MINING
	LM Statistics (Q-Stat)
1	3.30
2	4.04
3	5.24
4	5.67
5	7.10
6	7.25
7	7.32
8	7.61
9	8.27
10	9.08
11	10.84
12	18.29

13	18.33
14	18.46
15	18.57
16	19.31

White test was used to examine the variance problem. As can be seen from Table 7, we can not reject null hypothesis in which there is homoscedasticity, since probability value is greater than 0.05.

Table 7: **White Heteroscedasticity Test**

MINING	F Statistics	Probability
	0.35	0.95

Short-term dynamics among the series with no cointegration relationship were analyzed by Granger causality test. For this purpose, first of all, it is necessary to determine the appropriate length of stay which does not have problems such as the variability of the uncontrolled VAR model, that is, the presence of reverse roots within the unit circle and the variance with the autocorrelation. According to Akaike Information Criteria (AIC), the appropriate delay length was found to be 2<sup>4</sup>. According to the VAR model, which is predicted by 2 latencies, the modules (lengths) belonging to all inverse roots are located within the unit circle. In addition, according to LM series autocorrelation test and white heteroscedasticity variance test, there is no autocorrelation and heteroscedasticity problem of VAR model<sup>5</sup>.

Table 8: **Granger Causality Test Results**

<b>Dependent Variable: DLMINING</b>			
Exogeneous Variables	Chi-sq	df	Prob.
DLGOLD	10.6453	2	0.0049
DLCOPPER	7.5754	2	0.0226
DLSILVER	0.2242	2	0.8939
<b>Dependent Variable: DLGOLD</b>			
Exogeneous Variables	Chi-sq	df	Prob.
DLMINING	8.1675	2	0.0168
DLCOPPER	0.8597	2	0.6506
DLSILVER	1.9782	2	0.3719
<b>Dependent Variable: DLCOPPER</b>			
Exogeneous Variables	Chi-sq	df	Prob.
DLGOLD	3.5384	2	0.1705
DLMINING	1.6236	2	0.4441
DLSILVER	0.1301	2	0.9370
<b>Dependent Variable: DLSILVER</b>			
Exogeneous Variables	Chi-sq	df	Prob.
DLGOLD	0.3163	2	0.8537
DLCOPPER	0.3890	2	0.8232
DLMINING	11.8540	2	0.0027

**Note:** \*\*\*, \*\* and \* indicate statistical significance level in %1, %5 ve %10, respectively. df indicates degree of freedom.

<sup>4</sup> Table is presented in Appendix 2.

<sup>5</sup> Table is presented in Appendix 2.

The results of the Granger causality test are shown in Table 8. According to the results, it is seen that gold and copper prices are the reason of mining index. Mining index is the reason for both gold and silver prices. The share prices of the companies included in the mining index may increase from the expectation for profit growth before the prices of gold and silver when there is an expectation of an increase in gold and silver prices. Gold and silver prices are rising later. This may be a reason why the increase in mining shares caused granger causality in gold and silver prices.

In the short term, the profits of mining shares are affected by the change in precious metal prices. The fact that the market investors are focusing on the short term leads to the reflection of short-term changes in profits to market prices. On the other hand, the long-term increase in the shareholders' equity due to the accumulated profitability of the companies in the mining sector causes the share prices to increase continuously in an upward trend through the years. However, the prices of metals such as gold, silver and copper do not follow an ever-increasing trend in general. Maybe it is expected to increase as much as USD inflation over the years, but this increase will be much less than the increase in the equity of mining shares. The fact that a long-term relationship between the mining index and mine prices does not take place can be attributed to these reasons.

## **6. Conclusion**

The mining sector, which has a driving force for the manufacturing industry, contributes significantly to the economy in this respect. The presence of deep drilling, as well as potentially rich mineral reserves in terms of Turkey makes it more attractive for foreign investors the mining sector. Hence, the profitability of firms in the mining sector in Turkey lead to increase in the market value of these companies and this situation may cause the presence of international funds investing in these companies. On the contrary, the deterioration in commodity prices and the decline in the company values due to the different negative variables affecting the sector may lead to a decrease in the interest of the investor and the decline in the mining index.

At this study in Turkey, we aimed to detect and determine the effect of the price of gold, silver and copper prices on the Istanbul Stock Exchange mining index in period of 2013: 04 February 2018: December 13. Variables are determined as daily USD denominated price. The first study is to consider the standard ADF which ignores the structural breaks, and Fourier ADF unit root tests were applied to take into account the structural break. According to both methods, the first differences of the series were found to be stationary series. Then, the Banerjee cointegration test was performed to determine whether there was a long-term relationship between stationary series in which the first differences were taken. As a result of the analysis, it was found that there was no long-term relationship between metal prices (gold, silver, copper) and mining index. Therefore, it can be said that the mining index and metal prices did not move together in the long term. The short term relationship between the metal prices and the mining index has been investigated by standard OLS method. However, we didn't detect the long term relationship between the metal prices and the mining index, we got the positive significant relation between mining index with gold prices, copper prices in short run. According to the findings, it is determined that the silver prices have a negative effect on the mining index in short run. These results are supported by Ameer et al. (2018:370), Dogru and Uysal (2015:253), Gencer and Musoglu (2014) in literature. In addition, according to the results of causality test between the series, it is seen that there is a bidirectional relationship between gold prices and mining index. In addition, a one-way causality relation from copper prices to mining index and from mining index to silver prices has been identified.

Considering that the companies have a profit on average by years, it is expected that the prices of the companies entering the mining index will increase by years. Increasing profit amounts can be attributed to inflation and increasing consumption due to increasing population. However, the

prices of metals such as gold, silver and copper do not rise regularly, unlike company profits. Gold prices saw the price levels of 1900 USD / ounce in 2011 and decreased in the following years and loosened to 1200 USD / ounce levels in 2018. We can quantify this situation with an example; for example, consider a company that produces gold. For a better understanding of the situation, let us assume that the price of gold is 1000 USD / ounces for years and the cost of gold extraction is 500 USD / ounce. In this case, the company will make a profit of 500 USD per ounce, and if we consider that these profits are not distributed as dividends, the company will have accumulated a significant amount of profit as of years. In this case, even if the company's share value gold prices remained constant at 1000 USD / ounces, the value of the stock will increase regularly. Therefore, in this respect, it can be said that the increase or decrease in metal prices does not display a similar trend in the long-term mining index.

These results offer practical implications in terms of offering new investment tools for policy makers, portfolio managers and investors to ensure risk management as hedge instruments and investment diversification benefits.

As a result, while investigating the effect of gold, silver and copper prices over mining index XMADN within Borsa İstanbul stock exchange, data of different variables should be taken into consideration.

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## Appendix 1: Optimal Lag Selection Criteria

Lag	LR	FPE	AIC	SC	HQ
0	NA	3.44e-15	-21.95160	-21.93718*	-21.94622*
1	46.73403	3.41e-15	-21.96174	-21.88965	-21.93486
2	33.33384*	3.40e-15*	-21.96279*	-21.83302	-21.91439
3	20.56608	3.43e-15	-21.95513	-21.76768	-21.88522
4	23.88151	3.45e-15	-21.94979	-21.70467	-21.85837
5	19.17774	3.48e-15	-21.94124	-21.63845	-21.82832
6	8.612695	3.53e-15	-21.92541	-21.56495	-21.79098
7	14.11255	3.57e-15	-21.91342	-21.49528	-21.75748
8	11.97215	3.62e-15	-21.89997	-21.42415	-21.72252

Not: \* Indicates optimal lag according to selection criteria.

## Appendix 2: VAR (2) Model Stationarity Levels

Modulus (IZI)	LM Statistics			White Test	
	Lags	LM-Stat	Prob.	Statistics	Prob.
0.288875					
0.288875	1	20.1914	0.2117	160	0.0000
0.250865	2	21.8263	0.1489		
0.250865	3	19.7432	0.2320		
0.210903					
0.210903					
0.207396					
0.071364					

Not: IZI shows the length of the inverted root in the unit circle.

