Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Procedia - Social and Behavioral Sciences 210 (2015) 397 – 407
Procedia
Social and Behavioral Sciences

4th International Conference on Leadership, Technology, Innovation and Business Management

The chaotic relationship between oil return, gold, silver and copper returns in TURKEY: Non-Linear ARDL and Augmented Non-linear Granger Causality

Melike Bildirici[a] , Ceren Türkmen[b]

[a]*Yıldız Technical University, Social Science Institute, Istanbul, 34349,Turkey.*
[b]*Sakarya University, Geyve Vocational School, Sakarya 54187, Turkey.*

Abstract

The structure of the relationship between oil prices, gold price, silver price and copper price are not only important for economists but also for policymakers since it contributes to the policy debate on the link between variables and co-movement of the variables. In this paper, the relationship between oil prices and the price of gold and silver was analysed by BDS test, non-linear ARDL approach and two non-linear Granger causality methods for 1973:1 – 2012:11 period in Turkey. This study complements previous empirical papers. However, it differs from the existing literature with simultaneous use of nonlinear ARDL and two non-linear causality model: Hiemstra and Jones (1994) non-linear causality and augmented granger causality developed by this paper. The main findings of this paper are: (a) the gold price level showed positive asymmetric response to changes in the oil price in the short- - and long-run. The gold price probably possesses some market power and it is a means of store of value. Because of the *exception of gold,* there is a substantial sluggishness in the adaption to changes in demand. In the long run the *exception of gold* lags and adjustment costs should play a smaller part; b) there is a unique long-term relationship between oil prices and the prices of gold, silver and cooper; and (c) there is a unidirectional Granger causality between oil price and precious metal price.

Keywords: Oil Return, Gold Return, Copper Return, Silver Return, BDS Test, Non-linear ARDL, Hiemstra and Jones non-linear Causality, augmented non-linear causality

Peer-review under responsibility of the International Conference on Leadership, Technology, Innovation and Business Management

1. Introduction

Crude oil and precious metals such as gold, copper, and silver are strategic commodities whose price—and volatility—have received much attention. The volatility of the price of strategic commodities is very important for economists, policy makers, individual investors, and financial institutions of the world.

Crude oil is traded internationally among many different players, such as oil producing nations, oil companies, individual refineries, oil importing nations and speculators. Although the crude oil price is basically determined by its supply and demand (Hagen, 1994; Stevens, 1995), it is strongly influenced by many irregular events such as supply

---

[a*] Corresponding author. Tel. + 90-212-383-2527 fax. +90-212-259-4202

E-mail address: bildiri@yildiz.edu.tr

Peer-review under responsibility of the International Conference on Leadership, Technology, Innovation and Business Management
doi:10.1016/j.sbspro.2015.11.387

levels, economic growth of the U.S., political instability, OPEC decisions, etc. (Yu et al., 2007, 2008; Bildirici and Ersin, 2013).

Gold and silver are important precious metals for all countries at all times. Gold (and silver in some cases and places) is used as an industrial commodity, money, and a monetary asset. In addition to an industrial commodity, gold behaves as a way to store wealth, which is important especially in periods of political and economic instability. Gold value is accepted as a way of avoiding the increasing risk in financial markets, especially in crisis periods.

Baur and McDermott (2010) and Baur and Lucey (2010) found gold as a safe haven because of uncorrelated with financial assets during crises. Baur and McDermott (2010) determined that the return of gold is negative and related to periods of high volatility. According to their's results, gold is also a safe haven for US stocks during crises in 1987, 1997, and 2008. Sari et.al (2010) gold as a safe haven. Capie et al. (2005) tested the hedge ability of gold against exchange rate fluctuations. Their result determined a negative relationship between gold price and yen-dollar exchange rates. Levin and Wright (2006) investigated whether or not gold is a long-term hedge against inflation in Saudi Arabia, China, India, Indonesia, and Turkey.

Alternatively, the prices of precious metals and crude oil are influenced by common macroeconomic factors such as economic growth, political aspects, U.S. interest rates, exchange rates, inflation, and even people's psychological expectations, etc. (Hammoudeh et al., 2008).

The prices of crude oil and precious metals have great significance in determining the prices of other commodities; in contrast, the prices of precious metals depend on the rise-and-fall of oil prices. A sudden increase in oil prices causes an economic slowdown and the change of other commodity prices.

The importance of the economic behavior of crude oil and precious metals shows the economic importance of analyzing the relationship between these commodities. If the volatility of the prices of crude oil and precious metals (especially gold) is analyzed, information for forecasting the price trends of the whole commodity market can be obtained. The relationship between the price of crude oil and precious metals (especially gold) is one of the fundamentals that drives the prices of precious metals.

The aim of this paper is to analyze the relationship between crude oil return and the returns of precious metals such as gold, copper, and silver by using the non-linear ARDL and two non-linear Granger causality methods for Turkey. The price of crude oil and the price of gold, copper, and silver in Turkey exhibit a great deal of nonlinearity. On the other hand, some papers demonstrate that prediction performance might be very poor if traditional statistical and econometric models, such as linear regressions, are employed (Weigend, and Gershenfeld, 1994). This is because traditional statistical and econometric models are built on linear assumptions, which, as a result, fail to capture the nonlinear patterns hidden in the crude oil price series (Yu et al., 2008). It is a fact that the oil prices may not adjust instantaneously to newly available information. Further, low liquidity and the infrequent trading that occurs under imperfect markets could cause delays in response following the availability of new information (McMillan and Speight, 2006; Monoyios and Sarno, 2002; Lee, Liu and Chiu; 2008). Hamilton (1996) is an early study that drew attention to the nonlinear characteristics of oil prices by evaluating them in terms of regime changes in light of Markov Switching models. Barone-Adesi et al. (1998) suggested a semi-parametric approach for oil price forecasting. Adrangi et al. (2001) tested the presence of low-dimensional chaotic structure in crude oil, heating oil, and unleaded gasoline futures prices. Bildirici and Ersin (2013) employed LSTAR-LST- GARCH family models to examine the volatility of oil price.

The contribution of this paper is of several kinds. Present paper is the first one analysed the relationships between crude oil prices and the prices of precious metals such as gold, copper, and silver by using the non-linear ARDL and two non-linear Granger causality methods for Turkey. The non-linear ARDL and non-linear Granger causality methods are very important to explain the returns of precious metals. On the other hand, this paper uses nonlinear ARDL together with non-linear causality: Hiemstra and Jones (1994) non-linear causality and augmented granger causality method developed by this paper. This paper aggregates two methods and provide their simultaneous use[b].

Part II of this study is a literature review. Part III explore the relation between precious metals and oil Price in Turkey. Part IV discusses data and econometric methodology. Part V gives the empirical results, and Part VI concludes.

II. Literature Review

In the literature, oil prices were discussed from different perspectives. The literature are divided into two sub-groups as follows: a) the analysis of the relationship between oil prices and economic (and macroeconomic) variables; b) the analysis of the volatility of oil prices and the forecasting of oil prices. This paper is included into group 1

---

[b] In the real world, the nonlinear Granger Causality test is very important because there are some deficiencies in the linear Granger Causality test, as determined by Hiemstra and Jones (1994).

The oil prices have important effect on macroeconomic variables through different channels. On the one hand, oil prices affect macroeconomic variables on the other hand the price of oil that is a key input for most of the industries effects the cashflows to businesses and firms. The response of the precious metals to oil price shocks may also differ according to the origin of the shock; a demand-side shock which results from an economic expansion will have effect on both oil and precious metals pricies. A supply-side shock that is the result of decisions of OPEC countries, the political tensions, global economic state etc cause to economic crisis and lead to effect on precious metal returns.

Some papers have discussed whether or not the prices of oil and precious metals move together. Escribano and Granger (1998) tested the relationship between oil and silver prices and found a long-run relationship. Cai et al. (2001) explored whether or not interest rates, oil prices, consumer demand, the Asian financial crisis, and tensions in South Africa determined price volatility in the gold market. Nakamura and Small (2007) found that gold prices and crude oil prices were essentially random. Hammoudeh et al. (2007) explored the impact of crude oil and interest rates on the volatility of the price of gold, silver, and copper; according to their results, the impact of past oil shocks on gold, silver, and copper are different. Zhang et al. (2008) tested the volatility spillover effect of the U.S. exchange rate on the price of oil. Bekiros and Diks (2008) investigated the linear and nonlinear causal linkages between daily spot and futures prices for maturities from October 1991–October 1999 and November 1999–October 2007.

Soytas et al. (2009) examined the relationship between world oil prices, interest rates, exchange rates, and gold and silver prices in Turkey and determined that world oil price does not lead to volatility of gold price in Turkey. Zhang and Wei (2010) tested the relationship between the gold and crude oil markets and determined that the influence of crude oil on global development is wider than gold and the two market prices do not face a significant nonlinear Granger causality. Zhang and Wei (2010), Hsiao et.al(2013), Simakova(2011), Yue-Jun and Yi-Ming(2010) are other papers that investigate the causality between crude oil and gold market.

Wang et al. (2011) analysed the short-term and long-term interactions between gold price, exchange rate, oil price and stock market indices in US, Germany, Japan, Taiwan and China. Lee and Chang (2011) analyzed the relationships between the prices of gold and oil and the financial variables (interest rate, exchange rate, and stock price) in Japan. Baur and Tran (2012) analyzed the long-run relationship between gold and silver prices from 1970 to 2010 and determined the role of bubbles and financial crises in the relationship between gold and silver prices. Apak et al. (2012) explored the relationship among gold prices and other macroeconomic and financial variables and tested the question of whether gold is a safe haven or a hedge for investors in the period between 2000 and 2011. Lee et al. (2012) investigated asymmetric cointegration and the causal relationships between West Texas Intermediate Crude Oil and gold prices in the futures market during the period between May 1, 1994 and November 20, 2008. Their results showed that an asymmetric long-run adjustment exists between gold and oil. Baig et al, (2013) tested the relationship between gold prices, oil prices, and KSE100 return with the use of Johansen and Jelseluis Co-integration test and variance decomposition methods for the period of 2000 to 2010. Basit (2013) analyzed the relationship between the KSE-100 Index and the oil and gold prices for Pakistan. Hussin et al. (2013) investigated the relationship between crude oil price, Kijang gold price, and the FTSE Bursa Malaysia Emas Shariah index (FBMES) by the VAR method in Malaysia. Gençer and Kılıç(2014) analysed return volatility for the Istanbul Stock Exchange (ISE), the conjoint impact of oil and gold returns with multivariate CCC M-GARCH model

III. Precious Metals and Oil Price in Turkey

In this section, the structure of precious metals - the gold, copper, and silver markets in Turkey - is explained. Gold acts as a store of wealth, a medium of exchange, and a unit of value in Turkey. Gold is used as a hedging against inflation, crisis, political risk, and geopolitical risk. The current financial role, in addition to social and economic roles, of gold in Turkey is very important. Gold, copper, and silver are used in industrial components.

Since financial deregulation in 1989, the Turkish gold market has become important and interesting for financial and precious metal markets around the world (Omag, 2012). In this process, many important steps were taken. The first step was the establishment of the Istanbul Gold Exchange in 1993. The Capital Market Board issued the general regulation and operation principles of precious metals exchanges[c] (MDM; 2014). The second step, taken in 1995, the Istanbul Gold Exchange (IGE) (where gold is traded in an organized market) was opened and the authority to import gold was given to the IGE and The Central Bank of the Republic of Turkey. Thus, the gold price and gold exports and imports were liberalized. The IGE was a step to orient the metals into the financial system and to build the integration of the Turkish precious metals market with the international market. In the third step, in 1999, the trading of silver and platinum, in addition to gold, was initiated and/or released (IMMIB; 2014). With the IGE, local prices of precious metals conformed to international prices and the system gained a transparent structure. Borsa İstanbul A.Ş. was

---

[c] 40/A of Code of Capital Markets, number 2499 as amended by law number 3794

opened on April 4, 2013 through the merger of IGE and ISE (Istanbul Stock Exchange), under the provisions of the Capital Market Law No. 6362 (MDM: 2014, IAB; 2014 a and b).

Precious metals prices (especially gold prices) and oil prices have been volatile in Turkey and around the world since 1970 (especially after 1985). Oil and gold prices increased during the first and second oil crises, the Iranian revolution, and the 2008 crisis (Contuk et al., 2013). In 2009, gold reached is maximum price. In 2010, there was a 25 percent rise in the maximum price of gold, but the transactions volume decreased by 46 percent. The price of gold continued a rising trend and a recovery in transactions volumes was observed after 2010 (IGE;2014). After October 2011, gold reached its maximum price and began to fall again. In October 2012, gold prices rose and reduced again.

IV. Data and Econometric Methodology

4.1. Data

The data set used in this study was obtained from the World Bank and The Central Bank of the Republic of Turkey (CBRT) for Turkey. Silver and copper return were calculated based on gold – silver parity and gold – copper parity in the World. CBRT and World Bank data from 1973:1 through 2013:11 were used to find the monthly prices of oil, gold, silver and copper. Brent crude oil spot price is used to test the effectiveness of the used methodology. The main reason of selecting oil price indicators is that this crude oil price is one of the most famous benchmark prices, which are used widely as the basis of many crude oil price formule. The return of oil price (b) is measured as b=log(oil price_t/ oil price_{t-1}) and other variables (x) were calculated as x=log(x_t/ x_{t-1}).

4.2. Methodology

The paper is used to three test: BDS test for nonlinearity, nonlinear ARDL and nonlinear Granger Causality test.

4.2.1 **BDS** *Test*

The BDS test developed by Brock, Dechert and Scheinkman (1987) is the most popular test for nonlinearity. The BDS test have power against a wide range of nonlinear time series models. It was designed to test for the null hypothesis of independent and identical distribution (iid) for the purpose of detecting nonlinearity and non-random chaotic dynamics. Brock et.al(1991) and Barnett et.al (1997) determined that BDS test has power against a wide range of linear and nonlinear alternatives. If BDS test applied to the residuals from a fitted linear time series model, it can be used to detect remaining dependence and the presence of omitted nonlinear structure. The computations of BDS test follow the following procedures:

Given a time series x_t for t=1,2,---, Z and consider its m-history as

$x_t^m = (x_t, x_{t-1}, ..., x_{t-m+1})$

The correlation integral at dimension m can be estimated as followed

$$C_{\varepsilon,m} = \frac{1}{Z_m(Z_m-1)} \sum_{m\le s} \sum_{<z\le T} I(x_t^m, x_t^m; \in) \qquad (1)$$

where, Z_m=Z-m+1 and I(.) indicator function which is equal to one if $|x_{t-i} - x_{s-i}| < \in$ for i=0,1,. . . ,m-1 and zero otherwise.

It is estimated the joint probability as follows:

$$\Pr(|x_t - x_s| < \in, |x_{t-1} - x_{s-1}| < \in, \ldots, |x_{t-m+1} < x_{s-m+1}| < \in) \qquad (3)$$

The BDS test statistic can be stated as:

$$BDS_{\varepsilon,m} = \sqrt{Z}\frac{C_{\varepsilon,m} - C_{\varepsilon,1}^m}{S_{m,\in}} \quad (4)$$

where $S_{m,\in}$ sm, is the standard deviation of $\sqrt{Z}\,(C_{\varepsilon,m} - C_{\varepsilon,1}^m)$ and it is estimated as showed by Brock et.al(1997). BDS test is a two-tailed test, we should reject the null hypothesis if the BDS test statistic is greater than or less than the critical values (e.g. if α=0.05, the critical value = ±1.96).

4.2.2. Nonlinear ARDL Test

Galeotti et.al (2003), Bachmeier and Griffin, Van Treeck(2008), Shin et.al (2009), Karantininis et al. (2011), Saglio and Lopez(2012), Shin et al. (2012), Nimmo et.al (2010;2013) and Nguyen and Shin (2013) following Pesaran and Shin (1998) and Pesaran et.al (2001) developed the asymmetric ARDL (NARDL) model.

In Nimmo et al.(2010;2013), the asymmetric ARDL model is essentially an asymmetric extension of the linear ARDL approach to modeling long-run levels. Shin, et.al (2012) made two important contributions. First, they derived the dynamic error correction representation associated with the asymmetric long-run cointegrating regression, resulting in the nonlinear autoregressive distributed lag (NARDL) model. Second, they developed asymmetric cumulative dynamic multipliers that allow them to trace the asymmetric adjustment patterns following positive and negative shocks to the explanatory variables.

$$\Delta x_t = c + \delta\ x_{t-1} + \beta b_{t-1} + \sum_{i=1}^{m-1} B_i \Delta x_{t-i} + \sum_{i=0}^{m} \gamma_i \Delta b_{t-i} + \varepsilon_t \qquad (1)$$

$\Delta x \ = x_t - x_{t-1}$ is related to the last period's disequilibrium any variations induced by the changes in oil return. In ARDL model, when all variables are I(1), cointegration relationship is defined but variables mix I(0) and I(1), it is accepted that there is an evidence of a long-run relationship. ARDL model combine I(0) and/or I(1) variables in a long-run relationship rather than in a cointegrating relationship, bounds test methodology (Bildirici and Kayıkcı, 2012; Bildirici and Bakirtas, 2014). Granger and Yoon (2002) developed the concept of hidden cointegration, according to their theory when variables are not cointegrated in the conventional sense, their positive and negative of variables sums can be cointegrated with each other. The NARDL model allows one to examine the short- and long-run response of the oil return to each of the returns of gold, silver, copper and NARDL method detects hidden cointegration. NARDL employs the decomposition of the exogenous variable *X* into its positive and negative partial sums (Hammoudeh et. al:2014)

It is used to F test suggested by Pesaran and Shin (1998) and Pesaran, et.al (2001). F test based on the joint null hypothesis that the coefficients on the level variables are jointly equal to zero $H_0 : \delta = \beta = 0$

The asymmetric ARDL model may follow as:

$$x_t = \alpha + \beta^+ b^+ + \beta^- b^- + v_t$$

where β^+ and β^- are the associated long-run parameters . b_t is a kx1 vector of regressors decomposed as;

$$b_t = b_0 + b_t^+ + b_t^-$$

$$b_t^+ = \sum_{j=1}^{t} \Delta b_j^+ = \sum_{j=1}^{t} \max(\Delta b_j, 0) \ \ and \ \ b_t^- = \sum_{j=1}^{t} \Delta b_j^- = \sum_{j=1}^{t} \min(\Delta b_j, 0)$$

b_t+ and b_t- are partial sum processes of positive and negative changes in b_t. By associating to the ARDL, it is obtained the following model.

$$\Delta x_t = \delta\ x_{t-1} + \sum_{i=1}^{m} B_i \Delta x_{t-i} + \sum_{i=0}^{n} (\varphi_i^+ \Delta b_{t-i}^+ + \varphi_i^- \Delta b_{t-i}^-) + \vartheta^+ b_{t-1}^+ + \vartheta^- b_{t-1}^- + \varepsilon_t$$

where Δ and ε1t are the first difference operator and the white noise term. Superscripts "+" and "-" denote positive and negative partial sums computed following the previously mentioned decomposition method. bt is decomposed into b^+_t and b^-_t. The null hypothesis of no long-run relationship between the levels of x_t , b^+_t and b^-_t ($\theta = \theta^+ = \theta^- = 0$) is tested with the bounds testing procedure the irrespective if the regressors are I(0) and I(1) or mutually cointegrated. It follows two special states: $\theta = \theta^+ = \theta^-$ (long-run symmetry) and φ=φ+=φ- (short-run symmetry) for all i=0, - - - ,q.

Equation (3) determine possibility that the process exhibit asymmetries over both the short and long run and either only over long-run or only over short run. The second part of Equation (3) define the long-run relationship and first one contains the lags of the asymmetric all price in first differences. In Equation (3), it is possible to test rigidities in the short and/or in the long-run. F test of the joint null hypothesis is $H_0 = \delta = \theta^+ = \theta^- = 0$.

Accoding to Nimmo et.al(2010; 2013), this model has a number of advantages over the existing class of regime-switching models. First, once the regressors, bt, are decomposed into b^+_t and b^-_t, (3) can be estimated simply H_0: $\delta = \vartheta^+ = \vartheta^- = 0$ by standard OLS. Second, the null hypothesis of no cointegration among the variables in Eq.(3) are against the alternative hypothesis H_1: $\delta \neq \vartheta^+ \neq \vartheta^- \neq 0$. The null hypothesis of no long-run relationship between the levels of variables (H_0: $\delta = \vartheta^+ = \vartheta^- = 0$) can be tested with NARDL. Third nests the following two special cases: (i) long-run reaction symmetry where $\vartheta^+ = \vartheta^- = \vartheta$; (ii) short-run adjustment symmetry in which $\varphi_i^+ = \varphi_i^-$ for all i = 0,...,q. Both types of restriction can be tested easily using standard Wald tests; and (iii) the combination of long- and short-run symmetry in which case the model became the standard symmetric ARDL model developed by Pesaran and Shin (1989) and Pesaran et.al (2001) (For detailed information see Nimmo et.al (2013); Karantinnis et al. (2011).

Finally, the asymmetric ARDL model is used to obtain the asymmetric dynamic multiplier effects of a unit change in b+t and b−t on at defined by

$$z_i^+ = \sum_{j=0}^{i} \frac{\kappa x_{t+j}}{\kappa b_j^+},\ z_i^- = \sum_{j=0}^{i} \frac{\kappa x_{t+j}}{\kappa b_j^-} \quad i = 0,1,2... \qquad (4)$$

$z \to \infty,\ z_i^+ \to \beta^+ \ and\ z_i^- \to \beta^-\ where\, \beta^+ = -\vartheta^+ / \delta\, and\, \beta^- = -\vartheta^- / \delta$ Long-run multipliers are determine as

$\mathrm{L}_{op}^+ = \vartheta^+/\text{-}\delta,\quad \mathrm{L}_{op}^- = \vartheta^-/\text{-}\delta$ with long-run symmetry $\mathrm{L}_{op}^+ = \mathrm{L}_{op}^-$.

4.3. Non-linear Causality Analysis

Although non-linear ARDL approach determine whether or not existence of long-run relationship between variables, it doesn't show the direction of causality. The direction of causality is important for policy makers and governments. We used to two non-linear causality tests: Hiemstra–Jones nonlinear causality test and the causality model developed by in this paper.

The linear causality tests have some shortcomings. Hiemstra and Jones (1994) who point out that one of the shortcomings of the linear causality tests showed their inability to detect the nonlinear relationships between macroeconomic variables. Baek and Brock (1992) and Hiemstra and Jones (1994) suggested the nonlinear Granger causality test approach. In pursuit of pioneering papers, some papers have found it favorable and used it in macroeconomic perspectives. For example, Ma and Kanas (2000), Kyrtsou and Terraza (2003), Kyrtsou and Labys (2006), Rashid (2007), Bildirici (2013), used non-linear Granger causality[d].

Hiemstra–Jones Non-Linear Causality Test

Hiemstra and Jones test (1994), modified Baek and Brock (1992) approach by reducing series' mutually and individually iid property, hence allowing short term dependence. In other words, Hiemstra and Jones (1994) test tries to determine the existence of nonlinear dynamic relations among variables by testing.

Hiemstra–Jones test is can be expressed as follows; if ,it implies a rejection of nonlinear Granger causality running from oil price (X) to precious metal returns (Y).

For an observed bivariate time series {(Xt, Yt)}, t = 1, . . . , T, the Hiemstra-Jones test consists of choosing a value for e and testing

$$\Pr\left(\left\|X_t^m - X_s^m\right\| \text{p } e, \left\|X_{t-Lx}^{Lx} - X_{s-Lx}^{Lx}\right\| \text{p } e, \left\|Y_{t-Ly}^{Ly} - Y_{s-Ly}^{Ly}\right\| \text{p } e\right) = \Pr\left(\left\|X_t^m - X_s^m\right\| \text{p } e \middle| \left\|X_{t-Lx}^{Lx} - X_{s-Lx}^{Lx}\right\| \text{p } e\right)$$

by estimating the conditional probabilities as ratios of unconditional probabilities.
In order to denote the test statistic, estimators of the joint probability ratios are expressed with an additional index n, where n = T + 1 − m − max(Lx, Ly).
Hiemstra and Jones W statistic can be indicated as;

$$W = \sqrt{n}\left[\frac{\mathrm{C}_1\left(m+L_x,L_y,e\right)}{\mathrm{C}_2\left(L_x,L_y,e\right)} = \frac{\mathrm{C}_3\left(m+L_x,e\right)}{\mathrm{C}_4\left(L_x,e\right)}\right]^a \sim N\left(0,\sigma_Y^2\left(m,L_x,L_y,e\right)\right) \quad (4)$$

If the test statistic follows an asymptotical normal distribution, then we reject the null hypothesis that Y causes X
Let CS be the difference between two joint probability ratios; such that, CS = (C1/C2)−(C3/C4). The null of no causality is not rejected when CS is relatively close to zero. Under the assumption that {Xt} and {Yt} are strictly stationary, the asymptotic distribution of CS can be standardized as

$$TVAL = \sqrt{n} \times CS / \sqrt{\sigma^2} \sim \mathrm{N}\ (0,1).$$

Augmented Non-linear Granger Causality Method

Non-linear ARDL approach tests whether or not the existence of long-run relationship between variables, but it does not determine the direction of causality. It is used to non-linear Granger causality method since this paper aimed to determine the direction of causality.

Baek and Brock (1992) and Hiemstra and Jones (1994) put forward the nonlinear Granger causality test approach, many authors have found it favorable and used it in many perspectives. Kyrtsou and Labys (2006) determined a small

---

[d] Ma and Kanas (2000) explored the interaction between exchange rate and macroeconomic variables, using non-linear Granger causality. Rashid (2007) tested the linear and nonlinear Granger causality between stock price and volume in Pakistan. Kyrtsou and Terraza (2003), Kyrtsou and Labys (2006), determined the nonlinear causal relationship between crude oil price changes and stock market returns.

change in one variable can produce multiplicative and disproportionate impact on the variables in the presence of nonlinearity.

Ma and Kanas (2000) analysed the interaction between exchange rate and macroeconomic variables. Rashid (2007) discussed the linear and nonlinear Granger causality between stock price and volume in Pakistan. Kyrtsou and Terraza (2003), Kyrtsou and Labys (2006) used M-G approach to determine the nonlinear causal relationship between crude oil price changes and stock market returns. It was used the two-step procedure from the Engle and Granger model to examine the causal relationship between variables.

The Asymmetric Error Correction(AEC) model used to analyze relationships between the variables was constructed as follows:

$$\Delta \mathrm{x}=\mathrm{A}_{10}+\sum_{\mathrm{i}=1}^{\mathrm{m}} B_{1\mathrm{i}}\Delta \mathrm{x}_{\mathrm{t-i}}+\sum_{\mathrm{i}=0}^{\mathrm{m}}(\varphi_i^{+}\Delta \mathrm{b}_{t-i}^{+}+\varphi_i^{-}\Delta \mathrm{b}_{t-i}^{-})+\zeta \mathrm{ECT}_{t-1}+\varepsilon_{1\mathrm{t}} \tag{5}$$

$$\Delta \mathrm{b}=\alpha+\sum_{\mathrm{j}=1}^{\mathrm{m}} \lambda\Delta \mathrm{b}_{\mathrm{t-i}}+\sum_{\mathrm{i}=0}^{n}(\beta_i^{+}\Delta \mathrm{x}_{t-i}^{+}+\beta_i^{-}\Delta \mathrm{x}_{t-i}^{-})+\zeta_2 ECT_{t-1}+\varepsilon_{2\mathrm{t}} \tag{6}$$

where residuals εt are independently and normally distributed with zero mean and constant variance and ECTt-1 is the error correction term resulting from the long-run equilibrium relationship. ζ is a parameter indicating the speed of adjustment to the equilibrium level after a shock. It shows how quickly variables converge to equilibrium and it must have a statistically significant coefficient with a negative sign.

The error correction model (AEC) should be a starting point for the causality analysis. Granger causality can be examined in three ways: (1) short-run or weak non-linear causalities are detected by testing $H_0: \varphi_i^{+} = \varphi_i^{-} = 0$ and $H_0: \beta_i^{+} = \beta_i^{-} = 0$ for all i and j in Equations 5 and 6; (2) long-run non-linear causalities are represented by the ECMs in equations. The coefficients of the ECMs represent how fast deviations from the long-run equilibrium are eliminated following changes in each variable. Long-run causalities are examined by testing $H_0=\zeta=0$ and $H_0=\zeta_2=0$; (3) strong non-linear causalities are detected by testing $H_0: \varphi_i^{+} = \varphi_i^{-} = \zeta = 0$ and $H_0: \beta_i^{+} = \beta_i^{-} = \zeta_2 = 0$ for all i and j in Eqs. 5 and 6.

V. Econometric Results

The following unit root tests were used: the Augmented Dickey-Fuller (for which the null hypothesis is non-stationarity) as well as the Kwiatkowski-Phillips-Schmidt-Shin test (for which the null hypothesis is stationarity to determine the maximum order of integration).

Table 1. Unit Root and BDS Test Results

	Augmented Dickey-Fuller (*ADF*)		**Kwiatkowski- Phillips-Schmidt-Shin (*KPSS*)**		***BDS Test Statistics Embedding dimension (m)***				
	Level	*First Diff*	*Level*	*First Diff*	1	2	3	4	5
OP	-0.1475	-3.7586	0.95769	0.16996	18.62950	19.52922	21.87418	24.84141	29.04828
AP	-1.1753	-6.785	0.92072	0.17253	22.98321	27.19004	32.48792	40.17865	51.40859
SLV	-1.0078	-5.987	0.8843	0.16876	14.30119	14.77081	15.79473	17.18015	18.92521
COP	-0.9756	-4.753	0.8767	0.1178	16.66693	16.67532	16.87897	17.53170	18.48520
Critical values	1% level (-3.443442), 5% level (-2.867207), 10% level (-2.569850)		1% level(0.739000), 5% level(0.463000), 10% level(0.347000)						

The KPSS test was selected in order to have a cross-check. Both the unit root hypothesis and the stationarity hypothesis were examined by the KPSS test. This is distinguished between a series that appears to be stationary and series that appears to have a unit root.

Confirmatory analysis as joint testing accepts that the null of stationarity is accepted (rejected) and the null of non-stationarity is rejected (accepted); in this we have confirmation that the series is stationary (non-stationary) (Alimi and Ibironke, 2012).

The ADF and KPSS unit root tests concluded that the OP, AP, SLVR, and COP variables are stationary in the first differences.

Table 1 show the test statistic of BDS test for series analysed. The hypothesis of the test is as follow: H_1: *The data are not independently and identically distributed (i.i.d).* The first differences of the natural logarithm have been taken.

Table 1 show all the test statistics are greater than the critical values. In this condition, it is rejected the null hypothesis of i.i.d. The results determine that the time series in this paper are non-linearly dependent.

5.1. *Non-linear ARDL Results*

Table 2 shows the estimated long-run coefficient of the most suitable asymmetric equation. Table 2 reveals the arguments for valid long-run relationships among the variables. According to the results of Table 2, the null hypothesis of long-run and short run symmetry is clearly rejected at the 1% level. For Model 1, the null hypothesis of only long-run symmetry is clearly rejected at the 1% level.

The F-test indicates cointegration in both cases, while the BDM t-test cannot reject the null hypothesis of no long-run relationship. The models show that the Wald test is unable to reject long-run asymmetry. Therefore, in the long run, price changes will converge toward a symmetric long run relationship between these two price levels in models.

For Model 1, an important point is that the change of oil return is passed through to gold in the long-run. The pass through coefficient is the highest in state of increase of oil return. The increase in oil return causes a 0.64 increase in gold return and a 0.21 increase in silver return. A decrease in oil return causes a 0.29 decrease in gold return and 0.12 in silver return. We found evidence of short- and long-run asymmetries acting in opposite directions. Gold return tends to overshoot the following increase of oil return rate, because it reacts more sluggishly in response to a decrease in oil return. The sign and coefficient of copper, in the case of a decrease in oil return, determines movement with oil return. However, in case of an increase in oil return, the coefficient of copper is not significant.

The behavior of oil return is asymmetric, meaning that economic agents in Turkey are more willing to increase gold return instantaneously in case of an increase in oil return. Lee et al. (2012) determined that an asymmetric long-run adjustment exists between gold and oil.

In the case silver return, economic agents are willing to increase silver return instantaneously, but they do not have strong incentives to decrease silver return. It is determined that silver return, when oil return decreases, remains persistent. However, gold returns exhibit more flexible behavior than silver in case of increase and decrease of oil return. The important point is that the short-run negative asymmetry is more persistent in Turkey. According to short-run coefficients, an increase in oil return is passed through to gold return. With a decrease in oil return, gold return shows persistent return behavior; that is, it gives a more sluggish response.

As noted by Shin, Yu, Nimmo (2012), the pattern of dynamic adjustment depends on a combination of the long-run parameters, error correction coefficient, and model dynamics. This means that in the short run only return increases and decreases are transmitted. The complete sluggishness of return reduction in the short run makes it possible to say that the market power might play a significant role in explaining the short run asymmetry.

op_{LR}^{+} and op_{LR}^{-} determines long-run multipliers. They indicate the speed of adjustment to the equilibrium level after the shock. This shows how quickly variables converge to equilibrium, and it must have a statistically significant coefficient with a negative sign smaller than one. The signs of the coefficient of the error correction terms range between -0.485 and -0.1075 for positive sign and between -0.31478 and -0.095907 for negative sign, which provides stability for the model. The error correction term shows a high speed of adjustment of any disequilibrium toward a long-run equilibrium state for gold, whereas equilibrium can be restated for copper after long periods.

Table2. Estimation Results

	Model 1: Dependent variable: AP			Model 2: Dependent variable: SLV				Model 3: Dependent variable: COP			
lx	0.96265 (2.3815)			.69829 (13.96)				-0.1834 (2.011)			
lop^{+}	0.637(1.785)			0.209(1.7387)				0.012(0.176)			
lop^{-}	0.285 (3.965)			0.077(1.656)				0.0162(1.8998)			
Δx_{t-1}	1.065 (2.997)			-0.1304(2.086)				0.123(0.046)			
Δop				-0.2008(2.18)				0.8314 (1.8507)			
Δop^{+}_{t-1}	0.389 (1.975)										
Δop^{-}_{t-1}	0.0113(2.065)										
op_{LR}^{+}	-0.485(2.2013)			-0.258(2.246)				-0.1075(1.989)			
op_{LR}^{-}	-0.31478(1.9785)			-0.1435(1.9901)				-0.09507(2.001)			
R^2	0.7687	***F***	9.001	***R^2***	0.7064	***F***	8.0574	***R^2***	0.6912	***F***	7.9874
SSE	0.08291	***W_{Ls}***	32.3546	***SSE***	0.00529	***W_{Ls}***	27.275	***SSE***	0.0089	***W_{Ls}***	29.1452
JB	1.287	***W_{KS}***	29.5126	***JB***	1.098	***W_{KS}***	1.1425	***JB***	1.07	***W_{KS}***	0.74523
ARCH	0.9245	***t_{BDM}***	-4.95	***ARCH***	1.56	***t_{BDM}***	-4.18	***ARCH***	3.33	***t_{BDM}***	-3.36
	Long-run and Short-run asymmetry			Long-run asymmetry				Long-run asymmetry			
Lop+ and Lop^{-} denote the long-run coeffcients associated with positive and negative changes of oil return. SSE = Standard Error of Estimate, SSR = Sum of Squared Residuals, JB = Jarque–Bera Test, ARCH = Autoregressive Conditional Heteroskedasticity. W_{LS} refers to the Wald test of long-run symmetry while W_{KS} denotes the Wald test of the additive shortrun symmetry condition. F denotes the Pesaran-Shin-Simith F test statistic for k=2. Upper-bound test statistic at 1%, 5% and 10% are 5.30, 3.83, 3.19.											

The probable cause is that the gold return possesses some market power as a means of storing value and as a monetary asset. Because of the exception of gold, there is a substantial sluggishness in the adaptation to changes in demand.

5.2. The Result for Granger Causality Test

Since there is a long-run relationship between variables, a causality relationship must exist in at least one direction. Table 4 summarizes the non-linear causality relationship between variables. Granger non-linear causalities were present implicitly via the ECT; however, the equilibrium indicates the presence of unidirectional causality going from one of the variables to another.

Table 3. Hiemstra–Jones Causality Test Results TVAL

Lag	Δop→Δ ap Δap →Δop		Δop→Δ slv Δslv →Δop		Δop→Δcop Δcop→Δop		Δap→Δ slv Δslv →Δap		Δap→Δcop Δcop→Δap	
1	3.19093*	0.18580	2.940143	0.1112	2.10093	0.10012	3.01123*	0.04253	2.33453*	0.112
2	3.83508*	0.4124	3.66425*	0.1175	1.89998	0.11112	3.3375*	0.4124	3.00121*	0.1124
3	1.90745	1.0856	1.12361	0.11745	1.00012	0.0111	107.458	1.2245	1.00121	0.00816
4	1.10142	1.00745	1.04125	0.00115	0.00745	0.00775	1.01425	1.0011	1.00011	0.00115
5	0.9431	1.0004	0.91201	0.0001	0.00114	0.00014	0.0789	0.00114	0.00125	0.0004
6	0.01425	0.08569	0.01005	0.00019	0.00001	0.0001	0.00112	0.00089	0.00011	0.00019

The Table 3 show results of the Hiemstra–Jones causality test results. The results depicted in Table 3 determine only 4 detected cases significant. The results imply the existence of possible dynamics of non-linearity between oil price and precious metal price, providing evidence about the presence of synchronicity in the feedback relationship dependence between variables analyzed. The positive type of non-linear dependence can easily be viewed. Feedback has a non-linear sources. A rise of oil price can cause anormal behavior of precious metal prices.

Table 3 determined that there is an important causal influence of dlop on dlap, dlslv and dlcop, because an increase in the delay is signal of high complexity. It is show a relatistic approximation of the dynamics that cause inherent non-linearity between oil price and precious metal price.

Table 4. Granger Causality

	Δop→Δ ap Δap →Δop		ECT→ Δop, ECT→ Δap		Δop, ECT → Δap, Δ ap , ECT→ Δ op	
Asymmetric Case for Positive Crude Oil Return Changes	8.425	0.956	12.756	10.756	107.586	1.123
Asymmetric Case for Negative Crude Oil Return Changes	15.746	1.789	16.758	15.623	12.456	1.756
	Δop→Δ slv, Δslv →Δop		**ECT→ Δop, ECT→ Δap**		**Δop, ECT→ Δslv, Δslv , ECT→ Δop**	
Asymmetric Case for Positive Crude Oil Return Changes	6.456	1.123	30.1698	1.998	76.536	0.1352
Asymmetric Case for Negative Crude Oil Return Changes	1.426	1.0789	10.1056	1.756	20.123	1.756
	Δop→Δ cop, Δcop →Δop,		**ECT→ Δop, ECT→ Δap**		**Δop, ECT → Δcop Δcop , ECT→ Δop**	
Asymmetric Case for Positive Crude Oil Return Changes	5.126	0.0756	1.123	0.789	1.1053	0.896
Asymmetric Case for Negative Crude Oil Return Changes	1.0013	0.456	1.19	0.07	1.765	1.326

According to the results, there are uni-directional causalities running from oil return to gold return in the asymmetric case for positive and negative crude oil return changes in short-long run and strong causality. Unlike this paper's results, Soytas et al. (2009) found the world oil return does not lead the volatility of gold return in Turkey. Lee et al. (2012) causality results determined that crude oil plays a dominant role. Baig et al. (2013) found no-causality between oil return and gold return in Malaysia.

In the case of negative and positive change of crude oil return, there is unidirectional causality running from oil return to silver return for weak, short, and long-run. In only negative change is there no-causality between oil return and silver return there is no causality between the returns of oil and copper in an asymmetric case for negative and positive crude oil return changes in all causality forms.

VI. Conclusion

This study used the asymmetric ARDL method and non-linear Granger Causality approach to analyze the relationship between oil returns and the returns of gold, silver and copper. It was used the two-step procedure to examine these relationships. The first step analyzed the long-run relationship between the variables by using the asymmetric ARDL approach. The second step used non-linear VEC model to test non-linear causal relationships.

The main findings of this paper are: there is a unique long-term or equilibrium relationship between oil returns and the return of gold and silver; non-linear causal relationships within dynamic non-linear error-correction model; M-G non-linear causality model determine additional evidence about the presence of synchronicity in the feedback relationship dependence between variables analyzed. Augmented non-linear causal relationship in the asymmetric case for positive and negative crude oil return changes. It is determined uni-directional Granger causality from oil return to gold return but in case of weak and strong Granger Causality.

The short-run return transmissions between the oil return and gold return have implications. Alternatively, for policy makers and for both local and global investors, the result of paper show that oil returns pass through gold returns

This analysis indicates unequivocally that the pass-through from the oil return to gold return exhibits for good monetary policy, the volatility of oil return should be controlled. CBRT must be used to monetary policy, when a crisis is caused by raising oil return and inflationary pressures arise, to alleviate the inflationary pressures in the gold return. Otherwise, the observed results in case of overshooting oil returns may affect the efficiency and credibility of the CBRT's policy. Moreover, oil return volatility leads to a deterioration in the balance of payments in Turkey, as in other oil importing countries

Reference

Alimi R.S. and Ibironke A, Dolado - Lütkepohl Causality Tests between Foreign Direct Investment and Economic Growth in Nigeria, (2012) http://mpra.ub.uni-muenchen.de/49277/

Adrangi, B., Chatrath, A., Dhanda, K. K., and Raffiee, K., Chaos in oil prices? Evidence from futures markets, *Energy Economics*, 23 (2001), 405-425.

Apak S., Akman V.,Çankaya S., Sönmezer S., The Case for Gold Revisited: A Safe Heaven or A Hedge ? Emerging Markets Journal, 2(2012), 28:1-8

Bachmeier L.J., J.M. Griffin. New Evidence on Asymmetric Gasoline Price Responses. The Review of Economics and Statistics. 85 (2003) 772-776.

Baek, E., Brock, W., A general test for nonlinear Granger causality: bivariate model. Working paper. Iowa State University and University of Wisconsin- Madison (1994)

Baig M.M., Shahbaz M., Imran M., Jabbar M., Ul Ain Q, Relationship between Gold and Oil Prices and Stock Market Returns, ACTA Universitatis Danubius, 9 (2013).

Baur D.G., D.T. Tran. The Long-run Relationship of Gold and Silver and the Influence of Bubbles and Financial Crises, WP Finance Discipline Group, UTS Business School, University of Technology. 172(2012).

Barnett, W.A., R.A. Gallant, M.J. Hinich, J.A. Jungeilges, D.T. Kaplan and M.J. Jensen, A Single-blind Controlled Competition Among Tests for Nonlinearity and Chaos, Journal of Econometrics, 82(1997), 157-192.

Barone-Adesi, G., Bourgoin, F., Giannopoulos, K., Don't look back, Risk 100–103 August 8 (1988).

Basit A., Impact of KSE-100 Index on Oil Prices and Gold Prices in Pakistan, IOSR Journal of Business and Management, 9(2013); 66 -69

Bekiros, S.D., C.G.H., Diks. The relationship between crude oil spot and futures prices: cointegration, linear and nonlinear causality, Energy Econ. 30(2008) 2673–2685.

Bildirici, M., Kayıkçı, F., Energy Consumption and Growth in Eastern Europe: ARDL Approach, Economic Research, 25(2012), 538-559.

Bildirici, M.E.; Bakirtas, T., The relationship among oil, natural gas and coal consumption and economic growth in BRICTS (Brazil, Russian, India, China, Turkey and South Africa) countries, Energy, 65(2014) , 134-144.

Bildirici M.,Ersin O., Forecasting oil prices: Smooth transition and neural network augmented GARCH family models, Journal of Petroleum Science and Engineering, (2013), 230-240.

Brock, W.A., W.D. Dechert and J.A. Scheinkman, A Test for Independence Based on the Correlation Dimension, mimeo.(1987).

Brock, W.A., W.D. Dechert, J.A. Scheinkman and B. LeBaron, A Test for Independence Based on the Correlation Dimension, Econometric Reviews, 15(1996), 197-235.

Cai, J., Cheung, Y-L., and Wong, M.C.S., What moves the gold market?, Journal of Futures Markets 21 (2001), 257-278.

Capie, F., Mills, T.C., and Wood G., Gold as a hedge against the dollar, Journal of International Financial Markets, Institutions and Money 15(2005), 343-352.

Contuk F., Burucu H., Güngör B., Effect of Gold Price Volatility on Stock Returns: Example of Turkey, International Journal of Economics and Financial Studies, 5(2013), 119-139.

Escribano, A. C. Granger, Investigating the relationship between Gold and Silver Prices, Journal of Forecasting 17 (1998) 81–107.

Galeotti M., A. Lanza, M. Manera, Rockets and feathers revisited: an international comparison on European gasoline markets, Energy Econ. 25(2003) 175-190.

Granger, C. W. J., Yoon, G., Hidden Cointegration, Economics Working Paper No. 2002-02. SSRN: http://ssrn.com/abstract=313831 or http://dx.doi.org/10.2139/ssrn.313831, 2002

Greenwood-Nimmo M.J., T.H, Kim, Y. Shin, T. Van-Treeck, Fundamental Asymmetries in US Monetary Policymaking: Evidence from a Nonlinear Autoregressive Distributed Lag Quantile Regression Model.

Hamilton, J. D., This is What Happened to the Oil Price-Macroeconomy Relationship, Journal of Monetary Economics 38 (1996), 215-220.

Hagen, R., How is the international price of a particular crude determined?, OPEC Review 18 (1994), 145–158.

Hiemstra C., J. Jones, Testing for linear and nonlinear Granger causality in the stock price-volume relation, J. Finance 49(1994) 1639–1664.

Hammoudeh S., Lahiani A., Nguyen D.K., Sousa R.M., Asymmetric and nonlinear passthrough of energy prices to CO2 emission allowance prices," Working Papers 2014-082, Department of Research, Ipag Business School.

Hussin M.Y., Muhammad F., Razak A.A., Tha G.P., Marwan N., The Link between Gold Price, Oil Price and Islamic Stock Market: Experience from Malaysia, Journal of Studies in Social Sciences ISSN 2201-4624 4(2013), 161-182. http://faculty.washington.edu/ezivot/econ584/notes/nonlinear.pdf

Istanbul Mineral and Metals Exporters' Association (IMMIB), http://www.immib.org.tr/en/associations-turkish-jewellery-association.html.

IAB, Precious Metals Market Development and Activities of the Market,http://www.iab.gov.tr/pmm.asp, 2014.

IAB, , Precious Metals and Diamond Market, Development and Activities of The Market, http://www.iab.gov.tr/docs/pmm_tr.pdf, 2014.

Karantininis K., K. Katrakylidis, M. Persson. Price Transmission in the Swedish Pork Chain: Asymmetric non linear ARDL, 2011 International Congress, European Association of Agricultural Economists.

Kyrtsou C., W. Labys, Evidence for chaotic dependence between US inflation and commodity prices', Journal of Macroeconomics, 28(2006) 256-266.

Kyrtsou C., M. Terraza, Is it possible to study chaotic and ARCH behavior jointly? Application of a noisy Mackey-Glass equation with heteroskedastic errors to the Paris Stock Exchange returns series, Computational Economics, 21(2003) 257-276.

Lanza A, Manera M, Giovannini M (2005). Modeling and forecasting cointegrated relationships among heavy oil and product prices. Energy Econ., 27: 831–848.

Lee T.H, Chang Y., 2011, Dynamic relationships between the price of oil, gold and financial variables in Japan: a bounds testing approach, MPRA No.33030, http://mpra.ub.uni-muenchen.de/33030/

Lee Y-H., Huang Y-L.,Yang H.J, The Asymmetric Long-run Relationship between Crude Oil and Gold Futures, Global Journal of Business Research, 6 (2012)

Lee, Y.H.,Liu, H.C., Chiu, C.L.,Nonlinear basis dynamics for the brent crude oil markets and behavioral interpretation: a STAR-GARCH approach, Int.Res.J. Finance Econ.14 (2008), 51–60.

Levin, E.R. and Wright R.E. 2006. Short-run and long-run determinants of the price of gold, World Gold Council. Research Study no. 32.

Ma Y., A., Kanas, Testing for nonlinear Granger causality from fundamentals to exchange rates in the ERM, J. Int. Finan. Mark. Inst. Money 10(2000) 69–82.

McMillan, D.G.,Speight,A.E.H.,2006.Nonlinear dynamics and competing behavioral interpretations: evidence from intraday Ftse-100 index and futures data, J. Futures Mark. 26(2006), 343–368.

Metals and Diamond Market, http://borsaistanbul.com/data/kilavuzlar/PRECIOUS_METALS_DIAMOND_MARKET.pdf.

Monoyios, M.,Sarno,L.,Mean reversion in stock index futures markets: a nonlinear analysis, J.Futures Mark, 22 (2002), 285–314.

Nakamura.T. Small M., Tests of the random walk hypothesis for financial data, Physica A, 377(2007) 599-615.

Nguyen, Shin Y., Asymmetric Price Impacts of Order Flow on Exchange Rate Dynamics, SSRN: http://ssrn.com/abstract=1864506 or http://dx.doi.org/10.2139/ssrn.1864506.

Nimmo, Kim, Shin Y. and Treeck V., Nonlinear Autoregressive Distributed Lag (NARDL) Model, Asymmetric Interest Rate Pass-through, Great Moderation, http://ssrn.com/abstract=1894621 (2013).

Nimmo, Kim, Shin Y. and Treeck V., The Great Moderation and the Decoupling of Monetary Policy from Long-Term Rates in the U.S. and Germany, the Macroeconomic Policy Institute (IMK) WP, 2010.

Omag A., An Observation of the Relationship between Gold Prices and Selected Financial Variables in Turkey, Muhasebe ve Finansman Dergisi Temmuz(2012),195-206.

Pesaran H., Y. Shin. An autoregressive distributed lag modelling approach to cointegration analysis. In Econometrics and Economic Theory: The Ragnar Frisch Centennial Symposium, Strom S (ed.). Cambridge University Press:Cambridge (1998).

Pesaran M, Y. Shin. R.J. Smith. Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics 16(2001) 289-326.

Rashid A., Stock prices and trading volume: an assessment for linear and nonlinear Granger causality. J. Asian Econ. 18(2007) 595–612.

Saglio S., A., López-Villavicencio. Introducing price-setting behaviour in the Phillips Curve: the role of nonlinearities, MPRA, 46646(2012), http://mpra.ub.uni-muenchen.de/46646/.

Shin Y., B. Yu, M.J.Greenwood-Nimmo. Modelling Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Framework. Available at SSRN: http://ssrn.com/abstract=1807745 or http://dx.doi.org/10.2139/ssrn.1807745.

Soytas U., Sari R., Hammoudeh S., and Hacihasanoglu E., World Oil Prices, Precious Metal Prices and Macroeconomy in Turkey, Energy Policy 37(2009), p.5557-5566.

Stevens, P., The determination of oil prices 1945–1995. Energy Policy 23 (1995), 861–870.

Rashid A., Stock prices and trading volume: an assessment for linear and nonlinear Granger causality, J. Asian Econ. 18(2007) 595–612.

Van T. Treeck, Asymmetric Income and Wealth Effects in a Non-linear Error Correction Model of US Consumer Spending, IMK WP 6/2008, Hans- Bockler Foundation, Dusseldorf.

Weigend AS, Gershenfeld NA., Time Series Prediction: Forecasting the Future and Understanding the Past, Addison-Wesley, Reading, MA(1994).

Ye, M., Zyren, J., Shore, J., Forecasting crude oil spot price using OECD petroleum inventory levels, International Advances in Economic Research 8(2002), 324–334.

Ye, M., Zyren, J., Shore, J., A monthly crude oil spot price forecasting model using relative inventories, International Journal of Forecasting 21(2005), 491–501.

Ye, M., Zyren, J., Shore, J., Forecasting short-run crude oil price using high and low-inventory variables, Energy Policy 34(2006), 2736–2743.

Yu, L., Lai, K.K., Wang, S.Y., He, K.J., Oil price forecasting with an EMD-based multiscale neural network learning paradigm, Lecture Notes in Computer Science 4489(2007), 925–932.

Zhang, Y.J., Y. Fan, H.-T., Tsai, Y.-M.,Wei, Spillover effect of US dollar exchange rate on oil prices, J. Policy Modelling. 30(2008) 973–991.

Zhang Y.J., Wei., Yi-Ming. The crude oil market and the gold market: Evidence for cointegration, causality and price discovery, Resources Policy. 35(2010) 168-177.