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Dynamic linkages between strategic commodities and stock market in Turkey: Evidence from SVAR-DCC-GARCH model

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ABSTRACT

After the financial liberalization in the emerging economies, their stock markets have grown very rapidly in terms of value and volumes. However, a sharp increase in the prices of strategic commodities like oil and gold can have negative effects on the macroeconomics of the emerging economies and their stock markets. This study analyses the dynamic relationship between oil, gold and stock market returns in Turkey. It particularly investigates volatility spillover from oil and gold to the Borsa Istanbul Stock Exchange Index after the global financial crises. Movement of the BIST index with the international oil and gold prices are examined by using different versions of the SVAR-DCC-GARCH framework. The bootstrap causality test which accounts for the non-normal distribution of errors is utilized to specify the SVAR model. Our results support the presence of time-varying co-movement and volatility spillover from gold and oil to the Turkish stock market. Volatilities are high, and gold has stronger impact on the stock market than oil; therefore, gold cannot be used as a safe haven against volatility risk. The results imply that Turkey needs dynamic macroeconomic policies to manage the spillover effects of volatility after the global crisis.

1. Introduction

After the financial liberalization in the emerging economies, they have received significant capital inflows and the stock markets of these economies have grown very rapidly in terms of value and volumes. However, emerging market economies are more vulnerable to global events resulting in more volatile and uncertain conditions (Raza et al., 2016). A sharp increase in the prices of strategic commodities like oil and gold can have negative effects on the macroeconomics of the emerging economies in several ways.

An increase in international crude oil prices increases general price levels and inflation in the oil importing countries. Gold is usually considered as a hedge against inflation. Therefore, economic agents in these countries increase their gold holdings in the expectation of a further rise in inflation. A rise in oil price increases the oil export revenues of the oil exporting countries and their demand for gold increases because of its risk easing characteristics. Accordingly, an increase in the oil price leads to a rise in global demand for gold, leading to an increase in the gold price. Furthermore, since the start of electronic trading of oil and exchange-traded funds across all commodity markets in 2006, investors' demand for oil and other commodities has increased enormously. Investors have an extensive list of options; in addition to holding bonds and stocks, they have also started investing in oil and other commodity exchange-traded funds.

As commodities have become an investment asset class, investors and other economic agents are primarily interested in the interactions between gold, oil and the stock markets, given the exceptional booms and busts in commodity prices. A number of portfolio managers now include gold, oil, and equity in their portfolios to boost their risk-adjusted returns (Jain and Biswal, 2016). Furthermore, based on considerable evidence on the hedge and safe haven properties of gold, and to a lesser extent of oil, investors often hedge the downward risk of their equity portfolios using these two commodities (Chkili, 2016; Kanjilal and Ghosh, 2017). Many studies have also examined the volatility linkages between oil, gold, and stock prices (see Aboura and Chevallier, 2015; Jain and Biswal, 2016; Singhal and Ghosh, 2016).

Turkey is a significant oil importer and consumer of gold. The country is the 16th leading oil importer country in the world (CEIC, 2017) and is also the world's fourth largest consumer of gold accounting for around 6% of global consumer demand. It is estimated that Turkish households have physically accumulated and stored at least 3500 tons (US$145.3 bn) of gold (Hewitt et al., 2015). The Turkish people are culturally-traditionally related to gold. It plays an important role in weddings and other aspects of daily life, while gold is also demanded

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for religious reasons, and for hedging against inflation and currency depreciation.

Gold demand in Turkey is sensitive to price and income changes. Consumers react quickly to changes in gold prices. They buy when the domestic price low and take profits when domestic prices are high. During higher growth period demand for the gold increase because people choose to save a portion of their rising income in gold. The state of the economy is an important driver of gold demand. However, an increase in expected inflation and currency weakness also has an important influence on the demand.

Turkey has been the world's second largest exporter of gold jewelry. Its primary export market is the Middle East, but it also exports to the US, Germany, Russia and other Commonwealth of Independent States countries. These jewelry exports have had a positive impact on Turkey's current account balance.

Gold is also part of the central bank's policy at the center of the Turkish financial system. The Turkish Central Bank (TCMB) implements a reserve option mechanism (ROM) as an innovative monetary policy tool. The ROM permits commercial banks to hold a portion of their required domestic currency reserves in either gold or foreign currency. The ROM mechanism aimed at limiting fluctuations in the exchange rate, encouraging banks to accumulate foreign currency and gold for adverse shocks. The inclusion of gold in this policy framework has increased gold reserves, mobilized Turkey's stock of gold, and improved liquidity in the banking system. However, the new policy framework has been criticized at least for two reasons; it is overly complex for market participants, and the transfer of commercial banks' reserves to the TCMB could be a poor substitute for usual central bank reserves during periods of economic distress.

Fluctuation in international prices of gold and oil could have a significant impact on the stock market and other macroeconomic variables of Turkey. While oil prices give rise to input costs, volatilities of strategic commodities may have a destabilizing effect. This study provides new evidence from Turkey by using the SVAR-DCC-GARCH framework. The importance of our econometric approach lies in its focus on the dynamic relations between the volatilities of commodities and stock index.

Our sample period is from January 1, 2009, to December 31, 2017. This sample allows us to provide a recent view on the volatility relationships across international commodity markets and the Turkish stock market. Compared to previous studies, this study, provides insights from the post-global financial crisis period, which represents a very interesting period for crude oil, gold, and equity markets in Turkey. In fact, during this period, the price of an ounce of gold had peaked in August 2011 and then declined by about one-third. Crude oil, which had peaked in April 2011, experienced an extreme decline and rise during the period under investigation.

The implications of the dynamics of time-varying volatility spillover are very important for risk management, portfolio diversification, and hedging. A limited number of studies have examined the dynamic impacts of international commodity prices on the Turkish stock market. No study has focuses on the post-crisis era. Hence, this study aims to filling this gap and examines the time-varying volatility relationships and the dynamic correlation between oil returns, gold returns, and Turkish stock returns. In order to achive this aim, we use the Structural Vector Auto Regression -Dynamic Conditional Correlation - Generalized Autoregressive Conditional Heteroscedasticity (SVAR-DCC-GARCH) framework. Another contribution of this study is that it clarifies the empirical methodology with blocking the domestic variables' feedbacks on international variables and take the non-normality of standard errors into consideration for the causality. The empirical framework provides consistent and more accurate results.

The rest of the paper is organized as follows. Section 2 reviews the related literature. Section 3 presents the data and describes the empirical methodology. Section 4 highlights and discusses the results, and finally, Section 5 concludes the paper.

2. Literature review

The literature suggests that there are three channels in regard to the relationship between oil and gold prices: the inflation channel (Aye et al., 2017; Narayan et al., 2010; Tiwari and Sahadudheen, 2015; Le and Chang, 2016), the portfolio allocation channel (Reboredo, 2013; Ewing and Malik, 2013; Kim and Dilts, 2011) and finally, the export channel (Melvin and Sultan, 1990). One of the first works in this area was Cashin et al. (1999) which attempted to determine whether the prices of the seven commodities, which seem to be unrelated do in fact move together. The study suggested a strong correlation between oil and gold prices. There are many studies in the literature that support the strong relationship between oil and gold prices (Hammoudeh and Yuan, 2008; Šimáková, 2011; Lee et al., 2012). Narayan et al. (2010), Zhang and Wei (2010) and Shahbaz et al. (2017) identified that gold price is an estimator of the oil price and there is a unidirectional relationship.

Several studies have examined whether a change in oil prices affect stock returns. Huang et al. (1996) conclude that there was no relationship between the US stock exchange and oil prices in the 1980s. However, another study in the same year conducted by, Jones and Kaul (1996) highlighted a significant relationship between oil prices and stock returns for the UK, USA, Canada, and Japan in the postwar period. Kang et al. (2015) for the United States, Arouri et al. (2011) for the Gulf region (except Saudi Arabia), Boyer and Filion (2007) for Canada and Bjornland (2009) for Norway report a positive relationship between oil prices and stock market returns. Researchers have suggested that stocks are driven by oil prices dynamics (Sadorsky, 1999; Arouri and Nguyen, 2010; Chiou and Lee, 2009; Malik and Ewing, 2009; Khalfaoui et al., 2015; Fayyad and Daly, 2011; Cunado and de Gracia, 2014). Kilian (2009) and Kilian and Park (2009), claimed that supply and demand shocks in oil price have an asymmetric effect on the stock market. Recent studies indicate that the volatilities of the oil prices and stock markets are highly correlated (Boubaker and Raza, 2017; Malik and Hammoudeh, 2007; Kang et al., 2015).

On the other side, researchers have investigated the link between gold prices and stock market returns. In the literature, an important area of debate revolves around whether gold is a safe heaven against the risks of stock market returns. Some studies have demonstrated the hedging ability of gold; Sreekanth and Veni (2014) and Güngür and Ünalmış (2014) for India; Baur and Lucey (2010) for the US, UK, and Germany; and Baur and McDermott (2010) for developing and developed countries. Beckmann et al. (2015) showed that the hedging ability of gold could vary from country to country. Most of the empirical studies show that there is a unidirectional relationship between gold and stock market returns. Moreover, past gold prices are a good predictor of the stock returns (Patel, 2013; Kumar, 2017; Mensi et al., 2014) and prices and volatility are interacting with each other in the two markets (Arouri et al., 2015; Mensi et al., 2013).

Analyzing the relationship between commodities and stock markets using multiple assets enhances the results. In the literature, there are a number of studies supporting that both of gold and oil prices have influential effects on the financial returns (Chang et al., 2013; Le and Chang, 2016) and the volatilities in these markets interact (Raza et al., 2016). The relationships between international commodity markets and the stock markets of developed countries have been extensively studied in the literature. However, these relationships in developing countries have received minimal attention. For example, Masih et al. (2011) examined the relationship between oil and the stock market for South Korea, Faff and Brailsford (1999) for Australia and Papaetrou (2001) for Greece. Singhal and Ghosh (2016) confirmed the long run and causality relationship between oil, gold and stock return and volatilities, Jain and Biswal (2016) and Bouri et al. (2017) analyze volatility linkages for India.

The literature on the Turkish stock market and commodity market is scarce. Ozturk and Acikalin (2008) and Soytas et al. (2009) reported that gold act as a hedge against inflation in Turkey. Contuk et al. (2013) and, Gencer and Musoglu (2014) found a relation between the stock market and gold prices in Turkey. Likewise, Eryigit (2012) founds that stock returns and oil prices are related. Only two studies have examined the tripartite mechanism of oil prices, gold prices, and the stock market. First, Vardar et al., (2018) analyzed ten countries, including Turkey in order to explore the shock and volatility transmission mechanism between stock returns and a broad set of variables consisting of oil, natural gas, platinum, silver, and gold. By using the GARCH type model, the study showed that the effect of commodity prices on stock market returns became more significant in the post-crisis era. Second, Turksoy and Faisal (2017) use the ARDL cointegration test to examine the long-term relationship between these three variables and claimed that oil and gold prices converge to the returns of the stock market in Turkey. However, these studies have not taken into account the small country assumption in their analysis. Civcir and Ertac-Varoglu (2019) investigated world oil price shocks on the Turkish economy; their findings indicated that commodity price shocks have a significant effect on Turkish macroeconomic variables.

3. Data and methodology

In this study, we used the international daily prices of the gold, crude oil and Borsa Istanbul Stock Index (BIST) between January 1, 2009, to December 31, 2017, to analyze the dynamic correlation between stock returns and global commodity market returns in a post-crisis era in Turkey. The inflation-adjusted Brent crude oil price (USD/barrel), the gold price (USD/troy ounce), and Borsa Istanbul Stock Exchange 100 Index (USD, hereafter BIST100) were obtained from the Bloomberg Data service. We used the return values of these variables and calculated them by taking the log difference of the two consecutive periods. As the Borsa Istanbul is closed on official holidays in Turkey, for synchronization of the data, we dropped the respective oil and gold price observations for these specific days.

Fig. 1 provides a plot of pairs of crude oil price, gold price, and BIST100 index. Visual inspection of graphs shows that all the prices have increasing and decreasing trends over the period of study. Although the BIST100 index increased significantly in 2009 and 2010, this trend was reversed in 2011. Subsequently, there was a significant increase for 1.5 years, followed by a year of decline in 2014. The index was almost stable until 2016, but increased significantly in 2017. Gold prices also rose substantially during the 2009–2011 period; afterward, a downward trend continued until 2016. During 2016 and 2017, it started to increase gradually.

After the collapse of the oil prices in 2008, they began to recover gradually during 2009–2010. However, in 2011 crude oil prices escalated and remained relatively high until mid-2014. Towards the end of 2014, oil prices plummeted significantly and there was a small recovery at the beginning of 2015, then the decline continued until the beginning of 2016. It showed upward movements in 2016–2017.

Table 1 shows the descriptive statistics of gold, oil and stock return. The returns of all assets have near zero means. Oil has the highest volatility amongst all returns. The Jacque-Berra test statistics indicate that all returns have a non-normal distribution. The result of non-normality suggests that the bootstrap causality test should be used. Finally, these test results imply that a type of GARCH modeling can be fitted for examining them because of non-normality.

4. Methodology

This study uses the structural VAR-DCC-GARCH approach to study the time-varying correlations amongst the returns of oil, gold, and BIST 100 Index. These dynamic correlations show the volatility spillovers between variables. The empirical methodology consists of three stages. In the first stage, the multivariate structural VAR model is estimated and the residuals are obtained. As a second step, the residuals are standardized. The DCCGARCH process is estimated and dynamic correlations are obtained in the last stage.

In this study, returns are initially modeled with a structural vector autoregression framework. In the structural VAR framework, we assume that Turkey is a small country. This means that in the VAR system, the Turkish stock returns are affected by oil and gold returns, but these two variables are not affected by the Turkish stock returns. We tested this assumption by using the bootstrap causality test developed by Hacker and Hatemi (2006) which is a version of the Toda Yamamoto (1995) test. This test takes into account the non-normality of the residuals. The bootstrap causality test is applied by using a three variable VAR model regardless of whether the variables are stationary or not.

$$bist100 = \alpha_{10} + \sum_{i=1}^{k} \beta_{1i} bist100_{t-i} + \sum_{j=k+1}^{k+dmax} \gamma_{1j} bist100_{t-j} + \sum_{i=1}^{k} \delta_{1i} gold_{t-i} + \sum_{j=k+1}^{k+dmax} \theta_{1j} gold_{t-j} + \sum_{i=1}^{k} \vartheta_{1i} oil_{t-i} + \sum_{j=k+1}^{k+dmax} \mu_{1j} oil_{t-j} + \varepsilon_{1t} \quad (1)$$

$$gold = \alpha_{20} + \sum_{i=1}^{k} \beta_{2i} gold_{t-i} + \sum_{j=k+1}^{k+dmax} \gamma_{2j} gold_{t-j} + \sum_{i=1}^{k} \delta_{2i} bist100_{t-i} + \sum_{j=k+1}^{k+dmax} \theta_{2j} bist100_{t-j} + \sum_{i=1}^{k} \vartheta_{3i} oil_{t-i} + \sum_{j=k+1}^{k+dmax} \mu_{2j} oil_{t-j} + \varepsilon_{2t} \quad (2)$$

$$oil = \alpha_{30} + \sum_{i=1}^{k} \beta_{3i}\, oil_{t-i} + \sum_{j=k+1}^{k+dmax} \gamma_{3j} oil_{t-j} + \sum_{i=1}^{k} \delta_{3i} gold_{t-i} + \sum_{j=k+1}^{k+dmax} \theta_{3j} gold_{t-j} + \sum_{i=1}^{k} \vartheta_{3i} bist100_{t-i} + \sum_{j=k+1}^{k+dmax} \mu_{3j} bist100_{t-j} + \varepsilon_{3t} \quad (3)$$

The lag length of the VAR model of the bootstrap causality test is the sum of the optimal lag (k) and the maximum degree of integration (dmax) of the variables. Critical values of this test are obtained by the bootstrap method. The test provides efficient results in the presence of non-normality and no ARCH effects on the error terms.

The optimal lag length (k) in the VAR system (1) is determined by the average of the Hatemi-J and Hannan-Quinn information criteria (HJC). The Wald test is applied to the sum of the coefficients of each explanatory variable up to the maximum lag to determine whether the explanatory variable is the cause of the dependent variable or not. The causality relationship between the stocks, oil, and gold is tested with the help of $\delta_{1i}\, and\ \vartheta_{1i}$ coefficients.

After justifying the small country assumption via the bootstrap causality test, in the SVAR framework, we blocked the feedback from the domestic variable to the international variables. More specifically, while the Istanbul stock exchange returns are affected by oil and gold returns, oil and gold returns are not affected by the Istanbul stock exchange returns. Thus, oil and gold returns are only affected by each other and their own lags. A three variate reduced form SVAR (p) can be represented by

$$\Delta lnO_t = \alpha_{10} + \alpha_{11}^{o}\Delta lnO_{t-1} + \ldots + \alpha_{1p}^{o}\Delta lnO_{t-p} + \alpha_{11}^{g}\Delta lnG_{t-1} + \ldots + \alpha_{1p}^{g}\Delta lnG_{t-p} + \varepsilon_{ot} \quad (4)$$

$$\Delta lnG_t = \alpha_{20} + \alpha_{21}^{o}\Delta lnO_{t-1} + \ldots + \alpha_{2p}^{o}\Delta lnO_{t-p} + \alpha_{21}^{g}\Delta lnG_{t-1} + \ldots + \alpha_{2p}^{g}\Delta lnG_{t-p} + \varepsilon_{gt} \quad (5)$$

$$\Delta lnS_t = \alpha_{30} + \alpha_{31}^{o}\Delta lnO_{t-1} + \ldots + \alpha_{3p}^{o}\Delta lnO_{t-p} + \alpha_{31}^{g}\Delta lnG_{t-1} + \ldots + \alpha_{3p}^{g}\Delta lnG_{t-p} + \alpha_{31}^{s}\Delta lnS_{t-1} + \ldots + \alpha_{3p}^{s}\Delta lnS_{t-p} + \varepsilon_{st} \quad (6)$$

Where Δ represent the log difference, ε_{ot}, ε_{gt} and ε_{st} are the residuals from the restricted SVAR model for oil, gold and stock returns respectively. We used the Akaike's information criteria (AIC) for setting the optimal lag length of the structural VAR models. We estimated the

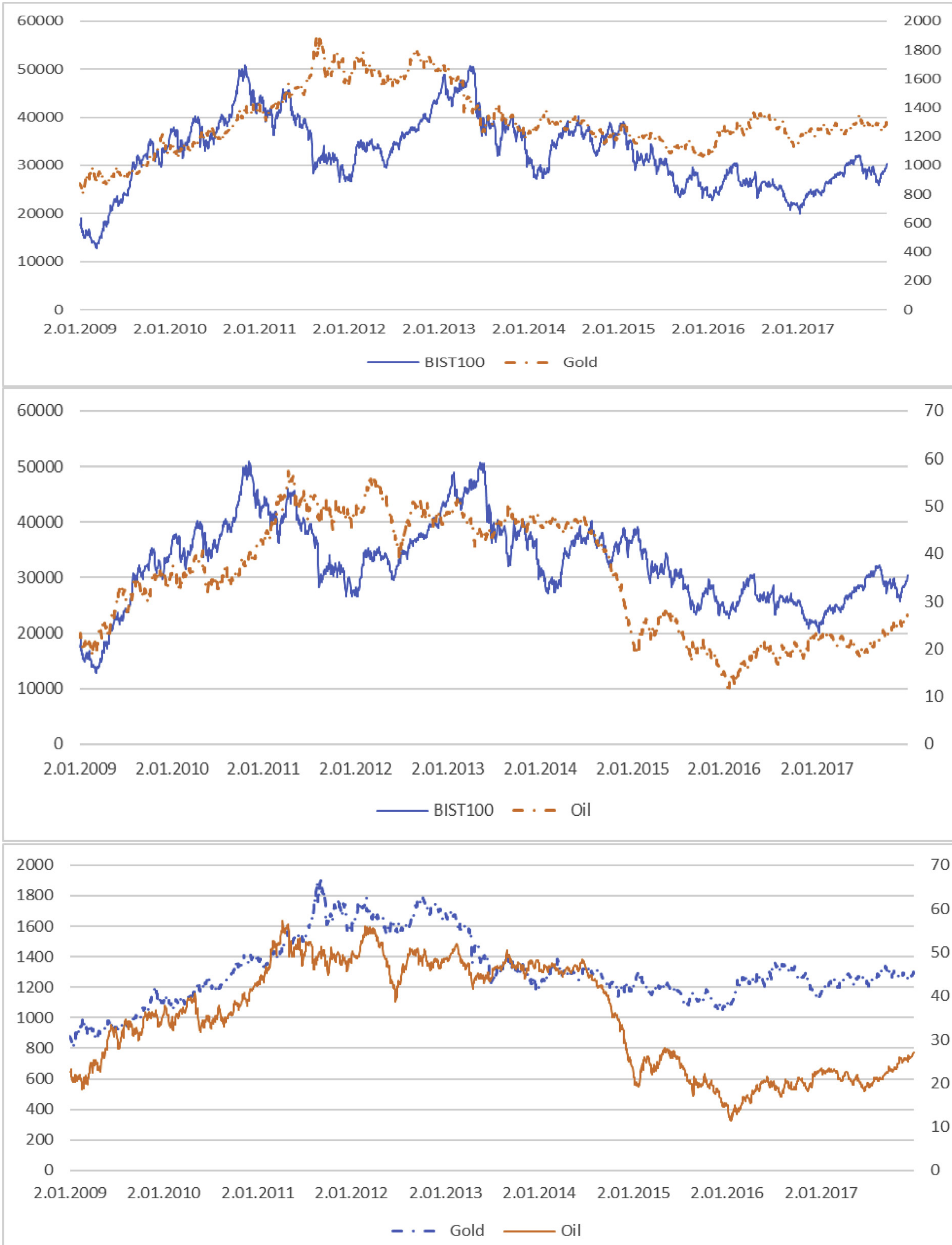

Fig. 1. International oil and gold prices, and BIST100 index. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)
Source: Bloomberg Data Service

SVAR model with Full Information Maximum Likelihood (FIML) with the small county restrictions and obtained the SVAR residuals. The SVAR residuals (ε_{it}) are standardized (de-GARCHing) by dividing with their corresponding GARCH conditional standard deviations ($\sigma_{i,t}$) as a second step. Specifications of GARCH (1,1), Exponential GARCH (1,1) and Threshold GARCH (1,1) have been used to standardize the residuals.

Table 1
Descriptive statistics for oil, gold and stock returns.

	*dlbist*100	*dlgold*	*dloil*
Mean	0.000241	0.000176	0.000081
Std. Dev.	0.019307	0.010610	0.020051
Skewness	−0.30949	−0.50117	0.04667
Kurtosis	5.32113	8.26305	5.46252
Jacque-Berra	544.378 (0.00)	2707.784 (0.00)	573.6570 (0.00)
Observation	2264	2264	2264

Note: Values in parenthesis are p values.

$$\varepsilon_{i,t} = \frac{\varepsilon_{i,t}}{\sigma_{i,t}} \tag{7}$$

A DCC-GARCH model that is a member of the multivariate GARCH family then uses these standardized residuals to estimate the dynamic conditional correlations. Engle and Kroner (1995) introduced a multivariate GARCH (M-GARCH) model for modeling the volatility transmission among multiple assets. This method can efficiently estimate the conditional correlation between the assets. The basic problem in estimating M-GARCH models is that the number of parameters to be estimated is huge and increases exponentially when the number of variables increases. To overcome this difficulty Engle et al. (1990) and Bollerslev (1990) introduced a constant conditional correlation GARCH model (CCC-GARCH). The CCC-GARCH model assumes that all conditional correlation among various assets are constant.

However, the conditional correlation may vary over time as they are updated by the conditional volatility. To resolve the difficulty of dimensionality in M-GARCH and the constant correlation problem in CCC-GARCH, Engle (2002) developed the dynamic conditional correlation GARCH (DCC-GARCH) model that eases the constant conditional correlation assumption and allows for time-varying correlations that are measurable with respect to the past values of the variables. In the DCC-GARCH model, the number of parameters does not increase exponentially but linearly, thereby solving the dimensionality problem. Recent literature (Guesmi and Fattoum, 2014; Creti et al., 2013, 2014; Singhal and Ghosh, 2016) also pointed out the limitations of considering co-movement of the stock market and commodity prices in a static framework. They identified that the co-movement between commodity prices and equity market is time varying in nature and therefore one needs to use a time-varying multivariate DCC GARCH methodology.

DCCGARCH comprises mean and variance equations. The mean equation is specified as:

$$r_t = \mu_t + \omega r_{t-1} + e_t \tag{8}$$

where r_t is the vector of the residuals of returns, μ_t is the conditional mean vector and e_t is the vector of residuals. In addition, the variance is estimated with the following equation:

$$h_t = c + \alpha e_{t-1}^2 + \beta h_{t-1} \tag{9}$$

where h_t is conditional variance and c is a constant. In this equation, while α is the parameter of ARCH effect and represents the short-run persistence of shocks to conditional variance, while β is the parameter of the GARCH effect that represents the long-run persistence of shocks to conditional variance. The variance-covariance matrix of the residuals in the DCCGARCH, H_t defines as following:

$$H_t = D_t R_t D_t \tag{10}$$

D_t is the diagonal matrix of the time-varying standard deviations from univariate GARCH estimations and R_t is the time-varying correlation matrix of variables. R_t contains conditional correlation coefficients that should be equal to or less than one. R_t can be defined as:

$$R_t = Q_t^{*-1} Q_t Q_t^{*-1} \tag{11}$$

$$Q_t = (1 - \theta_1 - \theta_2)Q^* + \theta_1 \varphi_{t-1} + \theta_2 Q_{t-1} \tag{12}$$

Q is the unconditional variance between the series, Q^* is the unconditional covariance between the series estimated in the first step, and φ_{t-1} is the empirical matrix of standardized residuals. θ_1 and θ_2 are implying the persistence of shocks. The sum of them which measure volatility persistence, is restricted to less than one.

5. Results and discussion

Before the estimation of the SVAR model, we tested for the presence of unit roots using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. The null hypothesis of the ADF and PP tests is that the series contains unit roots, while the KPSS test's null hypothesis is no unit root. Table 2 indicates that all the first logarithmic differenced series are stationary and they are used to estimate the SVAR model.

In the SVAR system, the BIST100 Index return has no impact on the international variables of oil and gold returns. This restriction comes from the small economy assumption. We test this assumption with the Hacker and Hatemi (2006) bootstrap causality test. Table 3 summarizes the results of the bootstrap causality tests, and it shows that causalities between oil, gold, and the BIST100 Index are bi-directional. The causality test results reveal that BIST100 Index return does not affect international oil and gold returns. This result supports the small economy assumption, and we use this information in the SVAR specification.

We used the FIML method to estimate the SVAR model with five lags, and diagnostic tests have been conducted on residuals for serial correlation and ARCH effect. These test results indicate that there is no serial correlation and ARCH effect in the residuals. Finally, we obtain DCC-GARCH estimations on standardized residuals of the SVAR equations. Table 4 presents the parameter estimates of the DCC-GARCH models for oil, gold, and BIST100 stock returns. Panel A of Table 4 contains results of the conditional variance equations for each variable on the first step and panel B shows the parameters of dynamic correlations estimations on the second step. Panel A shows that the parameters of the ARCH and GARCH effects, α and β, are positive and significant. In addition, their sum is less than one; therefore, the necessary condition for conditional variances to be finite was satisfied.

In these models, volatility persistence of the variables is measured by the sum of α and β. As the sum of these two parameters approaches one, the persistence of the variance increases. According to Panel A of Table 4, the positive and highly significant value of α and β confirms that volatilities of oil and BIST100 are highly persistent to shocks. At the same time, β is higher than α, which means that past variances are

Table 2
Unit root tests.

Variable	ADF Test			PP Test			KPSS Test	
	Intercept	Trend	None	Intercept	Trend	None	Intercept	Trend
dlbist100	−46.21 (0.0001)	−46.23 (0.00)	−46.21 (0.0001)	−46.22 (0.0001)	−46.24 (0.00)	−46.23 (0.0001)	0.220	0.084
dlgold	−47.87 (0.0001)	−47.90 (0.00)	−47.87 (0.0001)	−47.88 (0.0001)	−47.90 (0.00)	−47.87 (0.0001)	0.298	0.113
dloil	−48.45 (0.0001)	−48.46 (0.00)	−48.46 (0.0001)	−48.45 (0.0001)	−48.46 (0.00)	−48.46 (0.0001)	0.283	0.151

Note: Values in parenthesis represent the p-values. Critical values of KPSS test are 0.347, 0.463, 0.739 for %1, %5, %10 significance levels respectively.

Table 3
Bootstrap causality test results.

	Test Statistics	Causality
Gold to Bist100	6.991	Yes***
Oil to Bist100	3.209	Yes*
Gold to Oil	5.521	Yes*
Oil to Gold	2.290	No
Bist100 to Gold	1.199	No
Bist100 to Oil	0.692	No

Note: ***,** and * denote the significance at the 1%, 5% and 10% levels, respectively.

dominant over current variances. As can be seen from panel B of Table 4, both θ_1 *and* θ_2 parameters, which are associated with the short run and long run persistence of shocks on the dynamic conditional correlations, are highly significant across all the GARCH models. This indicates that the conditional correlations are time varying. High values of θ_2 for all equations indicate the long run persistence of volatility spillover between oil, gold and the stock market returns. Information criteria of the equations help us to choose the best specification. Residuals that are standardized with the EGARCH method have minimum values of the information criteria. For this reason, we use EGARCH estimation for obtaining dynamic correlations. The TGARCH model in which volatility can react asymmetrically to good or bad news, specifies the conditional variances as a multiplicative functional form of the past negative and positive innovations and is not preferred based on the information criteria.

Fig. 2 shows the time-varying conditional correlation between gold, oil and stock returns. The dynamic correlation between the oil returns and BIST100 returns is positive with the exception of two points but relatively low compared to gold in the sample period. Hence, several dramatic decreases can be observed in the correlation. The maximum value of the correlation is about 0.6 at the beginning of 2010, and the minimum value is −0.2 in mid-2013. One can also see that the correlation has two regimes in the figure. Until 2014, the correlation between oil and the BIST100 Index is relatively stable around at 0.3. After the year of 2014, there is a more volatile regime in the lower correlation level. The correlation is between 0.1 and 0.3 in this period. In 2017, there is a significant decrease in the trend of the correlation.

The relationship between gold and the BIST100 Index returns is strong and always positive. At the same time, the correlation is relatively stable. The correlation between gold and the BIST100 returns varies between a maximum of 0.75 and a minimum of 0.25; it only drops below 0 three times during the whole period. This strong correlation implies that volatilities of the returns largely spread from one to the other. It reveals the co-movements of gold and stock market volatility in Turkey. However, during the turbulent periods, the correlation decreases. Therefore, in general, gold has a low hedging ability against the stock market risks in Turkey. Nevertheless, during the crisis period gold protects against systemic risks, which reduce portfolio volatility and losses and produces gains in some systemic sell-offs.

As shown in the top of Fig. 2, the time-varying conditional correlation between oil and gold returns is mostly positive during the sample period. The conditional correlation is highly time varying both in a one-year period and across the period of years. As is obvious from the figure between the years 2011 and 2012 the correlation has the highest volatility, reaches 0.6 in mid-2011 and drops to −0.1 in mid-2012. The correlation between gold and oil gradually decreases until 2014. After 2015, we not only see a slight decrease again but also a more stable trend in the correlation. During the whole period under investigation the average is approximately 0.15.

Overall, the correlation between gold and BIST100, and oil and BIST100 returns are time varying. Therefore, assuming a constant correlation might be misleading. As can be seen in the figures, there are volatility spillover effects between markets. Volatilities of the markets are positively co-moving. Furthermore, the figures also show that all correlations amongst the variables are relatively more unstable between 2011 and 2013. The vast differences between the maximum and minimum values of correlation in this period indicate the higher risks in the financial markets and commodity markets. Another implication of the figures is that the dynamic correlation between gold returns and BIST100 index returns are far higher than those of the oil returns and BIST100 index returns.

For a robustness check, we alternatively estimated a VECM model with gold, oil and the stock market returns. The DCCGARCH results from the VECM model residuals did not show any significant change. Furthermore, we tried the cDCC GARCH estimator of Aielli (2013) due to the advantage of consistency but our results showed that there was no significant change on the correlations. In the second phase, alternative specifications were run while estimating the DCCGARCH model. There is no significant difference between the results of our model and

Table 4
DCC-GARCH results.

Panel A. Variance Estimations

	DLOIL			DLGOLD			DLBIST100		
	GARCH	EGARCH	TGARCH	GARCH	EGARCH	TGARCH	GARCH	EGARCH	TGARCH
Cst (M)	−0.01	−0.008	−0.009	0.02	0.02	0.02	0.02	0.02	0.019
ARCH (α)	0.02	0.03*	0.025	0.027	0.02	0.028	−0.003	0.001	0.004
GARCH (β)	0.54**	0.45***	0.435***	−0.003	−0.10	−0.009	0.98***	0.998***	0.986***
LR	−3196	−3196	−3197	−3202	–3202	−3202	−3523	−3537	−3537
$\alpha + \beta$	0.57	0.484	0.461	0.023	−0.07	0.018	0.986	1	0.99

Panel B. DCC Parameters

DCC Equation	GARCH	EGARCH	TGARCH
θ_1	0.03***	0.029***	0.029***
θ_2	0.92***	0.93***	0.93***
rho_oil_bist100	0.28	0.27	0.28
rho_gold_bist100	0.49	0.49	0.50
rho_oil_gold	0.24	0.23	0.23
AIC	8.378	8.377	8.379
SIC	8.421	8.420	8.438
HQ	8.393	8.393	8.394

Note: *,**,*** denote the significance at the 10%, 5% and 1% levels, respectively.

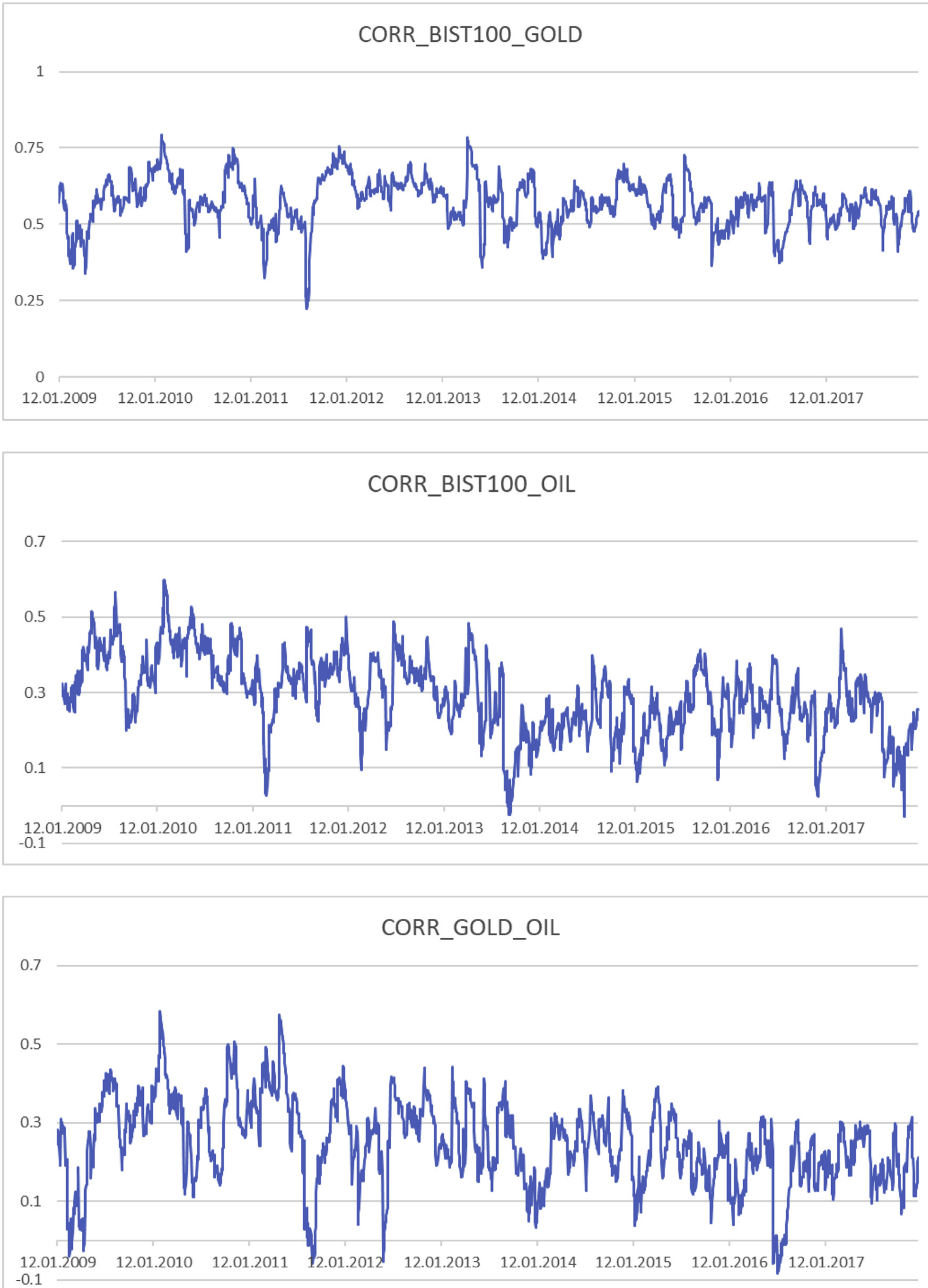

Fig. 2. Time varying correlations among oil, gold, and stock returns in Turkey. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)
Source: Authors calculations.

results of ARIMA (0,0) or GARCH (2,1) which are the other most frequently used specifications in the literature.

6. Conclusion

This study deals with the analysis of the dynamic relationship between oil, gold and stock market returns in Turkey after the global financial crisis. It particularly investigates volatility spillover from oil and gold to the Borsa Istanbul Stock Exchange Index after the global financial crises. Movement of the BIST100 return with the international oil and gold returns have been examined by using different versions of the SVAR-DCC-GARCH framework. The bootstrap causality test, which accounts for the non-normal distribution of errors is utilized to specify the SVAR model and report causality relations.

The parameters of dynamic correlations are significant in all cases indicating the significance of time-varying co-movements. Volatility in the time-varying correlation is the highest during 2011 and 2012. The large differences between the maximum and minimum values of correlation indicate that the risks in the financial markets are considerably high in this period. Furthermore, the time-varying correlation between the commodity markets and the Istanbul Stock Exchange is always positive during the period under investigation.

The outcomes of the study show that the spillover from the international crude oil market to the Turkish stock market is significant. The correlation between the oil and the Istanbul Stock Exchange return is relatively low but more volatile compared to the gold. On the other hand, the relationship between gold and the Istanbul Stock Exchange returns is very strong and always positive.

The policy implications of this study are important for policymakers and investment professional. Because Turkey imports a large volume of oil and consumes notable amounts of gold, commodity market dynamics have a direct effect on macroeconomic stability and the current account deficit in Turkey. Our findings show that a dynamic volatility spillover exists between international commodity markets and Turkish stock markets. This requires the construction of dynamic and practical policies by the Turkish policymakers to smooth the volatility spillover from international commodity to domestic variables. Since the gold price volatility spillover to domestic variables is high in Turkey, the authorities should increase gold reserves to smooth the volatility transmission to domestic variables. The results are also valuable to investors in reducing the risk of their portfolios. It can be concluded that oil price is an indicator for the volatility of the Istanbul Stock Exchange Index and although dynamic correlation weakens during market downturns, gold cannot be used as a safe haven against this volatility risk.

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