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EWI Working Paper, No 12/15

September 2012

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ISSN: 1862-3808

Crude Oil Price Shocks and Stock Returns:

Evidence from Turkish Stock Market under Global Liquidity Conditions

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Abstract

The purpose of this study is to investigate the impacts of crude oil price variations on the Turkish stock market returns. We have employed vector autoregression (VAR) model using daily observations of Brent crude oil prices and Istanbul Stock Exchange National Index (ISE-100) returns for the period between January 2, 1990 and November 1, 2011. We have also tested the relationship between oil prices and stock market returns under global liquidity conditions by incorporating a liquidity proxy variable, Chicago Board of Exchange's (CBOE) S&P 500 market volatility index (VIX), into the model. Variance decomposition test results suggest little empirical evidence that crude oil price shocks have been rationally evaluated in the Turkish stock market. Rather, it was global liquidity conditions that were found to account for the greatest amount of variation in stock market returns.

Keywords: Oil Price Shocks; Stock Returns; Liquidity; VAR Model

JEL classification: C58, G15, Q43, Q47

ISSN: 1862 3808

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1. Introduction

Since the first oil crisis experienced in 1973, the impact of oil price changes on macroeconomic activity has been widely discussed by academic researchers, investors and

policy makers. In this respect, the pioneering study of Hamilton (1983), which concludes that there is significant correlation between increase in crude oil prices and US recessions, has been accepted as the fundamental basis for the subsequent studies on the effects of crude oil price shocks on macroeconomic indicators such as GDP growth rate, inflation, and industrial activity[1]. According to these studies, the price of crude oil, which is the primary fuel of industrial activity, plays a significant role in shaping the countries' economic and political developments, not only by directly affecting the aggregate indicators, but also by influencing companies' operational costs, and thus their revenues. When the stock market is efficient, positive crude oil price shocks would negatively affect the cash flows and market values of companies, causing an immediate decline in the overall stock market returns.

Although there exists a major consensus in the literature that endogeneity is not an issue when analyzing the impacts of oil prices on stock markets of the countries apart from USA, some studies (e.g., Park and Ratti, 2008) suggest that there would, at least, be some sort of spillover from US or global financial markets to that of developed, mostly European, countries. It also seems plausible to consider this interrelationship when studying stock markets of emerging economies, which attract large amount of short-term capital movement from major economies. This paper extends the understanding on the issue of global spillover effects on the dynamic relationship between oil prices and stock market returns by employing data from one particular emerging economy, Turkey.

The purpose of this paper is to investigate the impacts of oil price shocks on the Turkish stock market for the period between January 1990 and November 2011 using the vector autoregression (VAR hereafter) model. A proxy variable capturing liquidity conditions in the global financial system is included into the analyses in order to examine the above-mentioned spillover effect. Since Turkey has limited domestic oil production and reserves, imports make up a significant portion of its oil consumption. Therefore, Turkish economy appears sensitive to oil price changes, similar to other developing and crude oil import-dependent countries. Moreover, over the last decades Turkish financial market, through a condense trade liberalization, has been attracting worldwide capital inflow. As of November 2011 foreign portfolio investments have been responsible for nearly 63% of total Turkish stock market capitalization.[2] Thus Turkish stock market returns have become sensitive to the shocks created in international financial markets.

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[1] Please see "Section 2. Literature Review" for corresponding studies.

[2] Data from website of Istanbul Stock Exchange (IMKB): http://www.ise.org/Data/StocksData.aspx.

One more reason for including financial liquidity is that financial, more specifically futures, markets have been the other major crude oil market since the early 1990s. This was the result of increasing volume of crude oil future contracts traded, which exceeded global oil production/consumption during late 1980s[3]. Since then crude oil prices have been determined in a manner that accounts for the effects of decisions made by investors, speculators, hedgers, and large investment funds in the future markets, as well as physical market conditions. Analyzing these "non-physical" market conditions, such as expectations about the market, global financial and economic indicators, would increase the possibility to shed some more light on the empirical variations in crude oil prices.

Therefore, a proxy for global financial liquidity will not only serve as an explanatory factor that influences stock market returns, but also be used to explain variations in oil prices. In the current study, the evidence of such tridimensional interaction, e.g. joint respond of stock returns and oil prices to liquidity, is investigated using the disentangling methodology proposed by Kilian and Park (2009).

Understanding the impact of crude oil prices on Turkish stock market is potentially beneficial for investors, market participants, regulators and researchers, as it is likely to exhibit characteristics different from those observed in well-documented developed markets. Thus, our study explores an underexploited area of potentially valuable research in Turkey with a very comprehensive data set, ranging from January 1990 and November 2011. This relatively long time horizon has been divided into three sub-periods[4] coinciding with specific oil price trends to allow testing of the performance of the Turkish stock market under different oil price regimes. Empirical results suggest that oil prices have significant impacts on Turkish stock market returns only during the third sub-period, during which crude oil prices represented extreme volatile structure. On the other hand, whenever the financial liquidity conditions are incorporated into the analyses, it is found out that liquidity is the most plausible explanation for the changes in both oil prices and stock market returns.

The remainder of this paper is organized as follows. The next section provides relevant literature about the relationship between financial markets and oil price shocks. Section 3 outlines the econometric methodology concerning VAR analysis and disentangling. The data

[3] Using data for global crude oil production/consumption from BP's Statistical Review of World Energy 2011 and for the volume of WTI crude oil futures contracts from NYMEX official website exact year can be derived as 1988.

[4] Sub-period I: January 1990–November 2001; Sub-period II: November 2001–July 2008; Sub-period III: July 2008–November 2011. Please see Section 4.1 for details of sub-periods.

set and empirical results are presented in section 4. Finally, section 5 contains discussion of results and concluding remarks.

2. Literature Review[5]

Since the study of Hamilton (1983), a plethora of studies have analyzed the interrelation between macroeconomic activity and oil price changes, most of which demonstrated a negative correlation[6]. Moreover, a number of researchers have examined the role of crude oil prices in monetary policy (e.g., Bernanke et al., 1997; Hamilton and Herrera, 2004) and impacts of oil prices on exchange rates (e.g., Chen and Chen, 2007; Coudert et al., 2008). However, there are comparably fewer studies on the relationship between oil prices and stock markets. According to the analyses, oil price shocks influence various industries' stock prices differently and the relationships between oil price shocks and financial markets are, for many countries, complex and ambiguous. A commonly held view is that an upward trend in oil price is beneficial for upstream oil companies, whose cash flows are directly related to the difference between oil price and crude oil lifting cost, yet has an adverse effect on downstream companies, including refining crude oil and marketing products, and many other industries.

A firm-specific study by Al-Mudhaf and Goodwin (1993) investigated the returns from 29 oil companies listed on the NYSE and demonstrated a positive impact of oil price shocks on ex post returns for firms with significant assets in domestic oil production. Further, Jones and Kaul (1996) examined whether the reaction of international stock markets to oil shocks could be justified by current and future changes in real cash flows, or changes in expected returns. They provided evidence that aggregate stock market returns in the US, Canada, Japan and the UK are negatively sensitive to the adverse impact of oil price shocks on the economies of these countries. Haung et al. (1996) analyzed the relationship between daily oil future returns and US stock returns by employing an unrestricted vector autoregression (VAR) model. The evidence suggests that while oil futures clearly lead some individual oil company stock returns, they have little impact on general market indices. Jones and Kaul (1996) reported that oil prices have a clear effect on aggregate stock returns employing quarterly data from 1947 to 1991, whereas Huang et al. (1996) found no evidence of a relationship between oil futures

[5] Please see Table A.1, summary of related literature, in Appendix.

[6] Mork, 1989; Kahn and Hampton, 1990; Huntington, 1998; Brown and Yucel, 1999, 2002; Gao and Madlener, 1999; Hamilton, 2003; Dickman and Holloway, 2004; Guo and Kliesen, 2005; Rogoff, 2006; Sill, 2007; Kilian, 2008; and Oladosu, 2009.

prices and aggregate stock returns using daily data from 1979 to 1990. However, Ciner (2001) challenged the findings of Huang et al., and argued for the need for further research to produce evidence from international equity markets to support the robustness of the results. He concluded that a statistically significant relationship exists between real stock returns and oil price futures, but that the connection is non-linear. Gjerde and Saettem (1999) demonstrated that stock returns have a positive and delayed response to changes in industrial production and that the stock market responds rationally to oil price changes in the Norwegian market. Faff and Brailsford (1999) used market model to investigate several industry returns in the Australian stock market, finding significant positive oil price sensitivity of Australian oil and gas, and diversified resources industries. In contrast, industries such as paper and packaging, banks and transport appear to display significant negative sensitivity to oil price hikes. Sadorsky (2001) indicated that stock returns of Canadian oil and gas companies are positively sensitive to oil price increases. Boyer and Filion (2009) employed a multifactor framework to analyze the determinants of Canadian oil and gas stock returns, finding similar results to Sadorsky.

More recently, Huang et al. (2005) investigated the effect of oil price change and its volatility on economic activities in the US, Canada and Japan. They indicated that when exceeding a certain threshold, oil price change and volatility possess significant explanatory power for the outcome of economic variables such as industrial production and stock market returns. Although El-Sharif et al. (2005) demonstrated how the oil prices have significantly positive impacts on oil and gas returns in the UK, the UK evidence for the oil price sensitivity existing in the non-oil and gas sectors is generally weak. In this context, Henriques and Sadorsky (2008) measured the sensitivity of the financial performance of alternative energy companies to changes in oil prices using VAR model in order to investigate the empirical relationship between alternative energy stock prices, technology stock prices, oil prices, and interest rates. They indicated that technology stock price and oil price each individually Granger causes the stock prices of alternative energy companies. Theoretically, in oil exporting countries, stock market prices are expected to be positively affected by oil price changes through positive income and wealth effects. In an analysis of the effects of oil price shocks on stock markets in Norway, Bjørnland (2009) argued that higher oil prices represent an immediate transfer of wealth from oil importers to exporters, stating that the medium to long-term effects depend on how the governments of oil producing countries dispose of the additional income. If used to

purchase goods and services at home, higher oil prices will generate a higher level of activity, and thus improve stock returns.

A negative association between oil price shocks and stock market returns in oil importing countries has been also reported in several recent papers. Nandha and Faff (2008) examined global equity indices with 35 industrial sectors, showing that oil price rises have a negative impact on stock returns for all sectors except the mining, and oil and gas industries. O'Neill et al. (2008) found that oil price increases led to reduced stock returns in the US, the UK and France. In a study of the connection between oil price shocks and the stock market for the US and 13 European countries, Park and Ratti (2008) reported that oil price shocks had a negative impact on stock markets in US and many European countries, while the stock exchange of Norway showed a positive response to the rise in oil prices. These authors also provided evidence that stock markets in oil exporting countries are less affected by oil prices relative to oil importing countries. The results of Chiou and Lee's (2009) study confirmed the existence of a negative and statistically significant impact of oil prices on stock returns. Their findings also provided support for the notion that oil shocks drive economic fluctuations, with the evidence indicating that with changes in oil price dynamics, oil price volatility shocks have an asymmetric effect on stock returns.

Examining whether the endogenous character of oil price changes affect stock market returns in a sample of eight developed countries, Apergis and Miller (2009) found evidence that different oil market structural shocks play a significant role in explaining adjustments in international stock returns.

Aloui and Jammazi's (2009) study focused on two major crude oil markets, namely WTI and Brent, and three developed stock markets, namely France, UK and Japan and was based on the relationship between crude oil shocks and stock markets from December 1987 to January 2007. The results indicated that the net oil price increase variable plays an important role in determining both the volatility of real returns and the probability of transition across regimes.

Contrary to the work done on developed markets, relatively little research has focused on the relationship between oil prices and emerging stock markets. Employing an error correction representation of a VAR model, Papapetrou (2001) concluded that oil price is an important factor in explaining the stock price movements in Greece, and that a positive oil price shock tends to depress real stock returns. Hammoudeh and Aleisa (2004) examined the relationship between oil prices and stock prices for five members (Bahrain, Kuwait, Oman, Saudi Arabia, and the United Arab Emirates) of the Gulf Cooperation Council (GCC) for the period 1994-

2001, while Zarour (2006) investigated the same countries during 2001 to 2005. Hammoudeh and Aleisa's findings suggested that most of these markets react to the movements of the oil futures price, with only Saudi Arabia having a bidirectional relationship. By analyzing the impulse response function, Zarour concluded that the sensitivity of these markets to shocks in oil prices has increased, with responses becoming more rapid after rises in prices. Finally, Maghyereh (2004) studied the relationship between oil prices changes and stock returns in 22 emerging markets, conducting VAR model from 1998 to 2004, without finding any significant evidence that crude oil prices have an impact on stock index returns in these countries. In contrast to this conclusion, Basher and Sadorsky (2006), analyzing the impact of oil price changes on a large set of emerging stock market returns for the period 1992 to 2005, proposed that emerging economies are less able to reduce oil consumption and thus are more energy intense, and more exposed to oil prices than more developed economies. Therefore, oil price changes are likely to have a greater impact on profits and stock prices in emerging economies. Arouri and Fouquau (2009) investigated the short-run relationships between oil prices and GCC stock markets. To examine the phenomena of stock markets' occasional non-linear response to oil price shocks, they examined both linear and nonlinear relationships. Their findings pointed to a significant positive relation between oil prices and the stock index of Qatar, Oman and UAE, but for Bahrain, Kuwait and Saudi Arabia, they found no such influence.

3. Methodology

This study employs VAR approach in order to examine the dynamic interactions between oil price shocks and the Turkish stock index, and compare results, which take into account global financial liquidity conditions with those that do not. The VAR model introduced by Sims (1980), presents a multivariate framework that expresses each variable as a linear function of its own lagged value and lagged values of all the other variables in the system. The main advantage of this approach is the ability to capture the dynamic relationships among the economic variables of interest. The methodology treats all variables as jointly endogenous, and for proper estimation in a multivariate stable VAR system, all variables employed in the model must be stationary or I(0) process. Although there are many tests developed in the time-series econometrics to test for the presence of unit roots, two tests in particular the Augmented Dickey-Fuller (ADF hereafter) test (Dickey and Fuller, 1979, 1981) and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS hereafter) test (Kwiatkowski et al., 1992)

have been employed to investigate the degree of integration of the variables used in the empirical analysis[7].

Case I: Simple Model

Here, we start with a simple model, which takes the relationship between oil prices and Turkish stock market into account and neglects effect of global liquidity constraints. In this model we needed to transform oil prices into shock variables. Besides linear ones, some nonlinear transformations of oil prices have also been proposed in the literature[8]. Therefore, in order to achieve robust empirical results we have used both linear and nonlinear transformations of oil prices. Two types of variables for oil price shocks employed in this study are log return and scaled oil price increase (SOPI hereafter). The log return of oil prices, o_t, is from $t-1$ to t calculated as;

$$o_t = \log(p_t/p_{t-1}) \tag{1}$$

where p_t denotes oil prices at time t. The oil price shock variable is also calculated by the method of SOPI developed by Lee et al. (1995).

$$SOPI_t = max\{0, (\hat{u}_t/\sigma_t)\} \tag{2}$$

where $\hat{u}_t$ is the residuals and σ_t is the square root of the volatility (σ_t^2), which are derived from equation system (3), and $SOPI_t$ captures positive oil price shocks for the subjected date. For this specification, GARCH (p,q) model, which has been first proposed by Bollerslev (1986) and has become popular, particularly, due to its explanatory power for dependence in volatility, is estimated as follows:

$$o_t = \mu + \sum_{j=1}^{q} \eta_j \, o_{t-j} + u_{i,t}$$
$$\sigma_t^2 = \alpha_0 + \sum_{k=1}^{q} \alpha_k \, u_{t-k}^2 + \sum_{j=1}^{p} \beta_j \, \sigma_{t-j}^2 \tag{3}$$

where u_t is white noise with $(u_t|u_{t-1}) \sim N(o, \sigma_t^2)$.

Furthermore, we have proposed a bivariate $VAR(p)$ system with daily return of Turkish stock index and two types of oil price change variable to analyze the variance decomposition structure. The model is written in the reduced form of structural VAR representation as follows:

$$rs_t = \beta_{10} + \sum_{i=1}^{p} \beta_{1i} rs_{t-i} + \sum_{i=1}^{p} \alpha_{1i} X_{t-i} + u_{1t}$$
$$X_t = \beta_{20} + \sum_{i=1}^{p} \beta_{2i} \, X_{t-i} + \sum_{i=1}^{p} \alpha_{2i} rs_{t-i} + u_{2t} \tag{4}$$

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[7] Since all the variables included in the VAR methodolog are I(0) process, Vector Error Correction Model (VECM) was not conducted in this paper.

[8] Mork, 1989; Lee et al., 1995; Hamilton, 1996.

where rs_t is the log-return of daily Turkish stock exchange index price, and X_t is the corresponding oil price shock variable, either o_t or $SOPI_t$.

Case II: Incorporating Global Liquidity Conditions

The dynamic system in equation (4) may lead to a conclusion that oil price shocks have significant impacts on stock returns, however this result may be biased if any variable, which affects both oil prices and stock returns in the long-run, is omitted. In order to avoid such a consequence, we should obtain a "purified" oil price shock variable, related only to the oil market itself. In order to obtain such purified oil market specific price shock variable we have employed disentangling methodology, proposed by Kilian and Park (2009). A proxy variable for global financial liquidity conditions, which is thought to be responsible for variations in oil prices besides physical oil market conditions, is incorporated into the analyses.

Chicago Board of Options Exchange's (CBOE hereafter) S&P 500 market volatility index, vix, is chosen as the proxy for global liquidity and its first difference, $dvix$, is used[9] in VAR framework:

$$o_t = \delta_{10} + \sum_{i=1}^{p} \delta_{1i} o_{t-i} + \sum_{i=1}^{p} \phi_{1i} dvix_{t-i} + u_{o,t}$$
$$dvix_t = \delta_{20} + \sum_{i=1}^{p} \delta_{2i}\, dvix_{t-i} + \sum_{i=1}^{p} \phi_{2i} o_{t-i} + u_{vix,t} \quad (5)$$

The first equation of this dynamic system allows to capture residuals, $\hat{u}_{o,t}$, which can be used as purified oil market specific shock variable. This residual series and $dvix_t$ are, further, used in the VAR framework proposed below instead of oil price shock variable, X_t, to examine their effects on Turkish stock index returns' variance decomposition structure. The proposed dynamic system, hence, becomes a tri-variate VAR with a following representation:

$$rs_t = \gamma_{10} + \sum_{i=1}^{p} \gamma_{1i} rs_{t-i} + \sum_{i=1}^{p} \eta_{1i} \hat{u}_{o,t-i} + \sum_{i=1}^{p} \varphi_{1i} dvix_{t-i} + \varepsilon_{1t}$$
$$\hat{u}_{o,t} = \gamma_{20} + \sum_{i=1}^{p} \gamma_{2i}\, \hat{u}_{o,t-1} + \sum_{i=1}^{p} \eta_{2i} dvix_{t-i} + \sum_{i=1}^{p} \varphi_{2i} rs_{t-i} + \varepsilon_{2t}$$
$$dvix_t = \gamma_{30} + \sum_{i=1}^{p} \gamma_{3i}\, dvix_{t-i} + \sum_{i=1}^{p} \eta_{3i} rs_{t-i} + \sum_{i=1}^{p} \varphi_{3i} \hat{u}_{o,t-i} + \varepsilon_{3t} \quad (6)$$

Variance decomposition analysis of this tri-variate VAR system will enlighten whether Turkish stock returns react to oil market specific shocks, or to shocks created in global markets due to the liquidity conditions.

4. Data and Empirical Results

4.1. Data

[9] First difference of CBOE's volatility index $dvix_t$, which is stationary, is used in the analyses since vix is I(1) process.

The data of this study consists of daily observations of ICE's Brent crude oil prices (p_t), log-return of ISE-100 stock market index (rs_t), and CBOE volatility index (vix_t). The 'National-100 Index' (ISE-100) is the main market indicator of the Turkish Stock Market. The data for Brent crude oil prices, ISE-100 index prices and VIX obtained from the US Energy Information Administration, the Matrix Database[10] and CBOE's official website, respectively. The data covers the period from January 2, 1990 to November 1, 2011, realizing a total of 5,194 observations. In order to examine stock market behavior under different oil price regimes, the data set is divided into three sub-periods. The first sub-period consists of 2833 observations, namely from January 2, 1990 to November 15, 2001, where oil prices follow a comparatively stable and horizontal trend, ranging between 9 US Dollars per barrel ($/bbl hereafter) and 41 $/bbl. The second consists 1604 observations from November 16, 2001 to July 11, 2008, during when the crude oil market, as with other commodities, witnessed historical record prices after an upward trend reaching to approximately 145 $/bbl. During the third, from July 14, 2008 to November 1, 2011, with the credit crunch period, crude oil prices immediately fell from 145 $/bbl barrel to nearly 40 $/bbl, and then increased again to approximately 125 $/bbl, representing high volatility, which led to extremely large positive and negative returns within a relatively short time period.

The descriptive statistics for Brent crude oil returns (o_t), ISE-100 stock index returns (rs_t), and first difference of CBOE's S&P 500 market volatility index ($dvix_t$) series are provided in Table 1. All three descriptive series display non-Gaussian characteristics with negative skewness for Brent crude oil returns and positive skewness for ISE-100 stock index returns, and CBOE's market volatility index. Moreover, all series exhibit excessive kurtosis, a fairly common occurrence in high-frequency financial time series data, and suggest that the observed excessive kurtosis may be due to heteroskedasticity in the data, which may be captured with the GARCH models. Excessive kurtosis would also explain the reasoning for high Jarque-Bera statistics, which reject the null hypothesis of normality for all return series. Values for coefficient of variation (CV) represent extreme and relatively high variance clustering around the mean of $dvix_t$ and o_t. The volatility index variable, by definition, captures variance of CBOE market; hence high CV is expected for $dvix_t$. On the other hand high CV value for o_t suggests further analyzing the variance structure of oil returns.

[10] Matriks is a licensed data dissemination vendor located in Turkey. It provides data and information on global financial markets as well as selected macroeconomic indicators.

Table 1. Descriptive Statistics of Sample Series

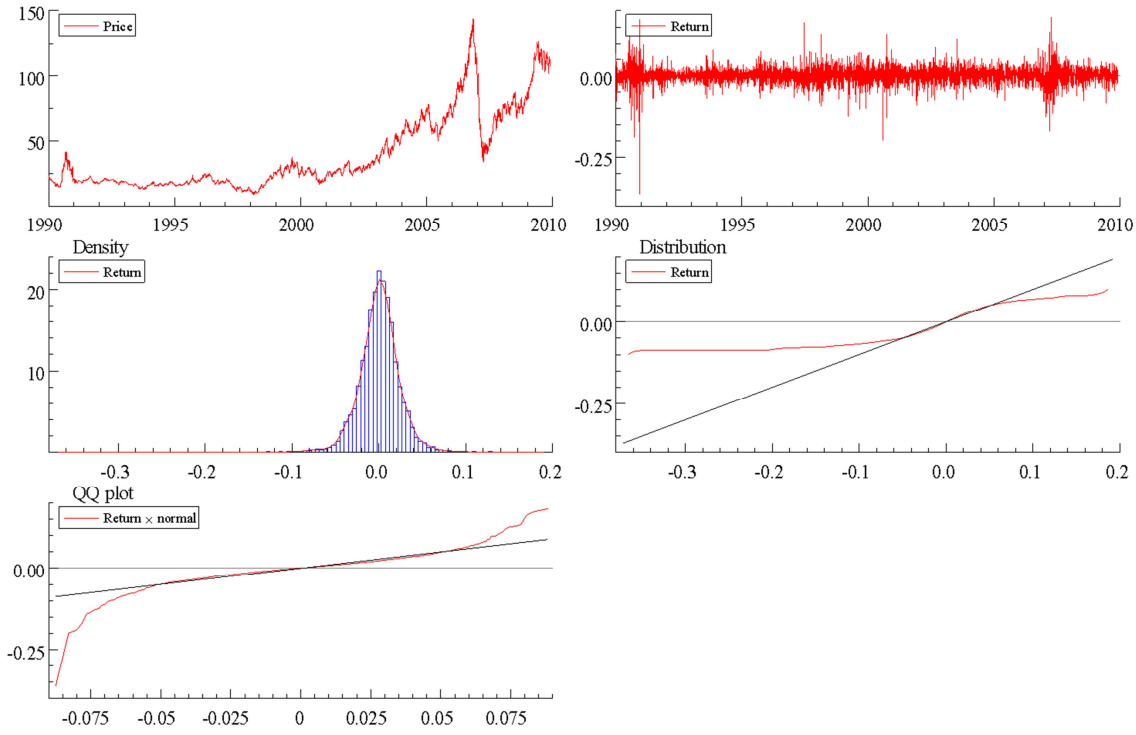
	o	rs	$dvix$
Mean	0.0003	0.0015	0.0034
Median	0.0008	0.0014	-0.0600
Maximum	0.1813	0.2655	16.5400
Minimum	-0.3612	-0.2033	-17.3600
Standard Deviation	0.0247	0.0290	1.5876
Coefficient of Variation	82.33	19.33	466.94
Skewness	-0.7742	0.0469	0.6606
Kurtosis	17.29	8.58	21.46
Jarque-Bera Stat.	44736.01*	6745.03*	74148.06*
# of observations	5193	5193	5193

Notes: SD indicates standard deviation. Jarque-Bera normality test statistic has a chi-square distribution with 2 degrees of freedom.

* denotes statistical significance at 1% level.

Volatility clustering is immediately evident from the graphs of daily oil returns, which suggests the presence of heteroskedasticity (Figure 1). The density graphs and the QQ-plot against the normal distribution show that return distribution exhibits fat tails, which the QQ-plots reveal are not symmetric. Oil prices show the greatest volatility and excess kurtosis, and the corresponding returns are positively skewed. This short but important preliminary descriptive and graphical analysis of the series indicates that the chosen statistical model should take into account the volatility clustering, fat tails and skewness features of the returns.

Figure. 1. Brent Crude Oil Prices, Returns and Tail Distribution with QQ-Plot



Note: The Brent crude oil price, daily returns, daily returns density and QQ-plot against the normal distribution. The time period is from 02.01.1990 – 01.11.2011

4.2 Empirical Results

Before investigating the impacts of oil price shocks on the stock market, we proceed to examine the stochastic properties of the series considered in the model by analyzing their order of integration on the basis of a series of unit root tests. Specifically, the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests are performed for the three sub-periods and the findings, summarized in Table 2, indicate that the first differences of all series are stationary, I(1) for all periods, allowing us to model the dynamic interactions with VAR model.

Table 2. Unit Root Test Results[11]

[11] Note that null hypothesis (H0: unit root exists in time series) for ADF test is the alternative hypothesis (HA) for KPSS test.

		Level		First Difference	
		ADF	KPSS	ADF	KPSS
Brent Crude Oil	Sub-Period I	-2.760	0.603*	-17.905*	0.038
	Sub-Period II	0.272	0.429*	-38.524*	0.137***
	Sub-Period III	-5.120*	0.338*	-27.608*	0.289*
	Whole Period	-2.852	1.341*	-11.308*	0.022
ISE-100	Sub-Period I	-2.129	0.976*	-13.685*	0.035
	Sub-Period II	-1.531	0.297*	-40.282*	0.136***
	Sub-Period III	-1.227*	0.407*	-12.278*	0.143***
	Whole Period	-2.157	1.434*	-14.754*	0.035
VIX	Sub-Period I	-4.181*	0.901*	-19.364*	0.018
	Sub-Period II	-2.002	0.802*	-17.837*	0.041
	Sub-Period III	-2.726	0.277*	-8.907*	0.053
	Whole Period	-5.046*	0.273*	-13.629*	0.014

*,** and *** indicate the statistical significance at 1%, 5% and 10% level, respectively.

As represented in equation system (4), VAR analysis is conducted on two types of oil price shock variables. In order to estimate $SOPI_t$ type shock variable, volatility of Brent crude oil returns is modeled with AR(1)-GARCH(1,1)[12] specification and the test results are indicated in Table 3. All of the parameter estimates of the AR(1)-GARCH(1,1) model are found to be highly statistically significant. The persistence in volatility as measured by sum of β_1 and α_1 in GARCH model is closer to unity for each period. As shown in Table 3, the estimated β_1 coefficient in the conditional variance equation is considerably larger than α_1 coefficient. The implication is that the volatility is more sensitive to the previous forecast of volatility in the market place.

Table 3. GARCH Variance Estimation Results

	μ	η_1	α_0	β_1	α_1

[12] Different AR(q)-GARCH(p,q) models were initially fitted to the data and compared on the basis of the Akaike and Schwarz Information Criteria (AIC and SIC) from which a AR(1)-GARCH(1,1) model was deemed most appropriate for modeling. The test results were not reported but they are available upon request from the authors.

Sub-period I	0.0001	0.0765*	0.0000*	0.8926*	0.1032*
Sub-period II	0.0016*	-0.0220	0.0000*	0.8620*	0.0400*
Sub-period III	0.0009	0.0013	0.0000**	0.9328*	0.0600*
Whole Period	0.0005**	0.0328**	0.0000*	0.9154*	0.0747*

*,** and *** indicate the significance at 1%, 5% and 10% confidence level respectively.

To check the performance of our model, ARCH-LM specification test was conducted on the normalized residuals, and there should be no ARCH effect left in the normalized residuals. Table 4 reports ARCH-LM test results for all three sub-periods. The results indicate that no serial dependence persists left in squared residuals of Brent crude oil returns after volatility modeling for sub-periods I and III, and also for the whole period. Although test statistics for sub-period II rejects the null hypothesis of "no serial dependence between squared residuals", it is statistically significant only at the 10% level of significance. Hence, the results suggest that AR(1)-GARCH(1,1) model is reasonably well specified to capture the ARCH effects.

Table 4. ARCH-LM Test Results

	Constant Term	Squared Residuals	F-Statistics	LM-Statistics
Sub-period I	1.003 (0.0000)	-0.004 (0.8280)	0.0472 (0.8280)	0.0473 (0.8279)
Sub-period II	1.037 (0.0000)	-0.041 (0.0986)	2.7306 (0.0986)*	2.7293 (0.0985)*
Sub-period III	1.013 (0.0000)	-0.010 (0.7773)	0.0801 (0.7773)	0.0803 (0.7769)
Whole Period	1.006 (0.0000)	-0.0072 (0.6026)	0.2712 (0.6026)	0.2712 (0.6025)

Note: The numbers in parenthesis are p-values. * denotes rejection of null hypothesis at 10%.

Since the volatility modeling has significantly succeeded in capturing the oil prices variance to a significant degree, the GARCH model and derived residual terms were further used in equation (2) to calculate $SOPI_t$ data. Then we employed VAR framework as in equation system in (4) with ISE-100 daily returns and two of the oil price shock variables, log returns (o_t) and $SOPI_t$, separately for each period. The results of Wald test for block significance and generalized variance decomposition of ISE-100 due to the oil price shocks are summarized in Table 5 and Table 6 respectively. According to the block-significance test results, oil prices found to have a statistically significant impact on stock returns only during the last sub-sample period. Yet the impact is rather small as represented in variance decomposition results.

Table 5. Block Exogeneity Wald Test Results for System in (4)

	Implied Coefficient Restrictions	$SOPI_t \rightarrow rs_t$ χ^2-stat	$o_t \rightarrow rs_t$ χ^2-stat
Sub-period I	$\alpha_{1i} = 0$, for $i = 1,2,3,4,5$	1.8095	1.5544
Sub-period II	$\alpha_{11} = 0$	1.3681	1.8308
Sub-period III	$\alpha_{11} = 0$	6.5633*	10.1163*
Whole Period	$\alpha_{1i} = 0$, for $i = 1,2,3,4,5,6$	4.3473	6.7199

Note: AIC determines the lag-length for VAR model as 5 for the first sub-period, 1 for the second sub-period, 1 for the third sub-period and 6 for whole period. *, ** and *** indicate the significance at 1%, 5% and 10% confidence level respectively.

Table 6. Generalized Decomposition of Variance of ISE-100 in Response to Oil Price Shock Variables

Days after	Sub-period I		Sub-period II		Sub-period III		Whole Period	
Impulse	$SOPI_t$	o_t	$SOPI_t$	o_t	$SOPI_t$	o_t	$SOPI_t$	o_t
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0344	0.0258	0.0854	0.1144	0.8094	1.2432	0.0148	0.0011
5	0.0486	0.0522	0.0861	0.1147	0.8098	1.2433	0.0148	0.0234
10	0.0553	0.0593	0.0861	0.1147	0.8098	1.2433	0.0148	0.1322

Moreover, in order to include global financial liquidity conditions into the analyses, VAR methodology between Brent crude oil prices and CBOE's S&P 500 volatility index (Eq. 6) was used to capture the variance decomposition, which is provided in Table 7. Although the block-significance test results[13] imply a unidirectional lead-lag relation between first difference of VIX and crude oil returns for all three sub-periods, it is only during the third sub-period that shocks from VIX create a comparatively higher variance on crude oil returns. On the other hand, regardless of the magnitude of the effect of global financial liquidity condition on variance of crude oil prices, it would still be considered possible to be able to capture residuals for oil returns that will be used as oil market specific price shocks purified of global liquidity constraints.

[13] According to the Block Exogeneity Wald Test, there exists a significant unidirectional causality from first difference of VIX to log-returns of Brent crude oil prices at 1% level for all three sub-periods.

Table 7. Generalized Decomposition of Variance of Brent Crude Oil Returns in Response to Global Financial Liquidity

Days after Impulse	Sub-period I	Sub-period II	Sub-period III	Whole Period
1	0.0000	0.0000	0.0000	0.0000
2	0.0912	0.6183	1.9680	0.1580
5	0.3545	0.6482	2.6108	0.2253
10	0.6819	0.6487	3.8427	0.3578

Note: AIC determines the lag-length as 7 for the first sub-period, 4 for the second sub-period, 1 for the third sub-period and 7 for the whole period.

Once oil market specific shock, $\hat{u}_{o,t}$, and financial liquidity shock, $\mathrm{dvix_t}$, are captured by the disentangling methodology, they are considered as two separate variables, along with stock prices in the VAR framework. Therefore, we have also used this multivariate framework to investigate the interrelationship between ISE-100 returns, oil price shocks and global financial liquidity shocks for the whole periods. The results, which are provided in Table 8, imply that the global liquidity statistically increases the variance of ISE.

Table 8. Block Exogeneity Wald Test Results for System in (6)

	Implied Coefficient Restrictions	$dvix_t \rightarrow rs_t$ χ^2-stat	Implied Coefficient Restrictions	$\hat{u}_{o,t} \rightarrow rs_t$ χ^2-stat
Sub-period I	$\varphi_{1i} = 0$, for $i = 1,2,3,4,5,6$	24.4151*	$\eta_{1i} = 0$, for $i = 1,2,3,4,5,6$	4.2867
Sub-period II	$\varphi_{11} = 1$	34.1651*	$\eta_{1i} = 0$	1.4218
Sub-period III	$\varphi_{11} = 1$	95.7573*	$\eta_{1i} = 0$	3.1124***
Whole Period	$\varphi_{1i} = 0$, for $i = 1,2,3,4,5,6$	85.0101*	$\eta_{1i} = 0$, for $i = 1,2,3,4,5,6$	6.0041

Note: AIC determines the lag-length as 6 for the first sub-period, 1 for the second sub-period, 1 for the third sub-period and 6 for the whole period. *,** and *** indicate the significance at 1%, 5% and 10% confidence level respectively.

Table 9. Generalized Decomposition of Variance of ISE-100 in Response to Oil Price Shock with Global Financial Liquidity

Days after	Sub-period I		Sub-period II		Sub-period III		Whole Period	
Impulse	$dvix_t$	$\hat{u}_{o,t}$	$dvix_t$	$\hat{u}_{o,t}$	$dvix_t$	$\hat{u}_{o,t}$	$dvix_t$	$\hat{u}_{o,t}$
1	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.6894	0.0052	2.0763	0.0874	10.0515	1.7774	0.1153	0.0415
5	0.7595	0.0259	2.1237	0.0897	10.3609	1.7871	0.1797	0.0884
10	0.9007	0.1582	2.1237	0.0897	10.3609	1.7871	0.2186	0.1542

According to the results from variance decomposition analyses, provided in Tables 6 and 9, three deductions can be made. First of all, the contribution of oil price shocks to the Turkish stock market is greater in the third sub-period than that of the first and second. This is an expected result such that, since oil prices move in a considerably more volatile manner in the third sub-period they create a higher impact on the ISE-100 returns. Secondly, the impact on variance decomposition starts with the second day of the impulse and dies out immediately without changing the structure of the trend of ISE-100. This may be the result of a non-linear relationship between oil prices and stock market returns, as proposed by prior researches (e.g. Arouri and Fouquau, 2009; Jawadi et al, 2010). Finally, the liquidity shock variable seems to be a considerable source of volatility for ISE-100 returns during the third sub-sample period, contributing more than 10%. This means that liquidity shocks, rather than crude oil prices, are the primary factor in stock market movements.

5. Discussions and Concluding Remarks

In this paper, we have investigated the impacts of crude oil price variations on the Turkish stock market using structural vector autoregression (VAR) model for the period between January 2, 1990 and November 1, 2011. ISE-100 index is used as a proxy for the performance of the Turkish stock market. The interactions between oil prices and ISE-100 have been analyzed by dividing this long time horizon into three sub-periods in order to test the response of Turkish stock market during different oil price regimes.

The empirical results suggest that the oil price changes significantly and rationally affect the Turkish stock market activity during only the third sub-period, which begins after the credit-crunch of 2008. Moreover, when the global financial liquidity conditions have been incorporated into the model, CBOE's market volatility index (VIX), which is used as an indicator for global financial liquidity, has been found to significantly affect both oil prices and ISE-100 returns. In this trivariate VAR analysis results also suggest that the most significant impacts of global liquidity shocks on stock market returns occur in the third sub-period.

The overall results suggest that the global financial liquidity conditions are the most plausible explanation for the changes in Turkish stock market returns. Although there exists some evidence that purified oil price shocks still have an impact on stock market returns, this effect is smaller and less significant than the liquidity constraints. This is an expected result provided that Turkish stock market, through widespread trade liberalization, has been

attracting worldwide capital inflow, which makes it more vulnerable to shocks created in global financial markets.

This study can be extended by obtaining a comparable firm-based dataset and by analyzing the behavior of each firm after oil price shocks. The empirical findings will prove to be extremely useful information to investors who need to understand the effect of oil price changes on certain stocks across industries, as well as for the managers of certain firms who require deeper insight into the effectiveness of hedging policies, which are affected by oil price changes.

Acknowledgements

The authors would like to thank to Prof. Felix Höffler, Prof. Oleg Badunenko, Prof. Adnan Kasman and the participants in the IAEE's 33rd International Conference for their helpful comments as well as to Simon Mumford for critically editing the manuscript.

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Appendix

Table A.1. Related Literature

Study	Sample Period	Frequency	Country of Study	Result
Al-Mudhaf and Goodwin (1993)	1970-1978	Monthly	29 oil companies listed on the NYSE	positive impact of oil price shocks on ex post returns for firms
Jones and Kaul (1996)	1947 – 1991	Quarterly	US, Canada, Japan and the UK	The reaction of US and Canadian stock prices to oil shocks can be completely accounted for by their returns however the evidence for Japan and the United Kingdom is puzzling
Huang, Masulis & Stoll (1996)	1983 – 1990	Daily	US	no evidence of a relationship between oil futures prices and aggregate stock returns
Ciner (2001)	1983 – 2000	Daily		significant relationship exists between real stock returns and oil price futures
Gjerde and Saettem (1999)	1974-1994	Monthly	Norway	stock market responds accurately to oil price changes
Faff and Brailsford (1999)	1983-1996	Monthly	Australia	significant positive oil price sensitivity of Australian oil and gas and diversified resources industries
Sadorsky (2001)	1983-1999	Monthly	Canada	positive significant relationship between oil price shocks stocks returns
Boyer and Filion (2009)	1995-2002	Quarterly	Canada	positive significant relationship between oil price shocks stocks returns
Huang, Hwang and Hsiao-Ping (2005)	1970-2002	Monthly	US, Canada, and Japan	oil price change and volatility possess significant explanatory power for the outcome of economic variables
El-Sharif, Brown, Burton, Nixon and Russell (2005)	1989-2001	Daily	UK	oil prices have significantly positive impacts on returns
Henriques and Sadorsky (2008)	2001-2007	Weekly	US	a shock to technology stock prices has a larger impact on alternative energy stock prices than does a shock to oil prices
Bjørnland (2009)	1993-2005	Monthly	Norway	a higher oil price increases stock returns

Nandha and Faff (2008)	1983-2005	Monthly	UK	oil price rises have a negative impact on stock returns for all sectors except the mining, and oil and gas industries
O'Neill, Penm, Terrell (2008)	2003-2006		Major OECD countries	While higher oil prices are found to adversely affect stock market returns in the US, the UK and France, the effects are positive in Canada and Australia as these countries are significant exporters of energy resources.
Park and Ratti (2008)	1986-2005	Monthly	US and 13 European countries	oil price shocks had a negative impact on stock markets in US and many European countries, while the stock exchange of Norway showed a positive response to the rise in oil prices
Chiou and Lee (2009)	1992-2006	Daily	US	negative impact of oil prices on stock returns
Apergis and Miller (2009)	1981-2007	Monthly	Australia, Canada, France, Germany, Italy, Japan, the UK, and the US	international stock market returns do not respond in a large way to oil market shocks
Aloui and Jammazi (2009)	1989-2007	Monthly	France, UK and Japan	rises in oil price has a significant role in determining both the volatility of stock returns and the probability of transition across regimes
Papapetrou (2001)	1989-1999	Monthly	Greece	positive oil price shock depresses real stock returns
Hammoudeh and Aleisa (2004)	1994-2001	Daily	Gulf Cooperation Council Countries	most of the GCC markets react to the movements of the oil futures price, with only Saudi Arabia having a bidirectional relationship
Zarour (2006)	2001-2005	Daily	Gulf Cooperation Council Countries	The response of oil returns to shocks generating by GCC markets was large
Maghyereh (2004)	1998-2004	Daily	22 emerging economies	stock market returns in these economies do not rationally signal shocks in the crude oil market
Basher and Sadorsky (2006)	1992-2005	Daily	21 emerging stock markets	oil price risk impacts stock price returns
Arouri and Fouquau (2009)	2005-2005	Weekly	Gulf Cooperation Council Countries	positive relation between oil prices and the stock index of Qatar, Oman and UAE