ANALYSIS OF EXTREME DEPENDENCE BETWEEN ISTANBUL STOCK EXCHANGE AND OIL RETURNS

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ABSTRACT

In this study, the relationship between oil price movements and Turkish stock market is investigated. Given the fact that Turkey is an emerging and oil dependent country, we analyze how the stock market behaves together with the fluctuations in oil prices. The study focuses on extreme observations and uses bivariate extreme value methodology in order to analyze the dependence structure between oil and stock market (ISE100). The residuals of autoregressive integrated moving average (ARIMA) models of stock market index and Brent oil returns are examined by using bivariate extreme value analysis over the period between 1988 and 2011. The overall period studied is analyzed by subdividing the period into two phases. We observe a higher dependence in the second phase (2000-2011), compared to the first phase (1988-1999). Our results show that in the second phase the extremes on the negative tails coincide more commonly compared to the extremes on the positive tails, which is in line with the current literature findings. Our findings suggest diversification opportunities for portfolio managers, as extreme observations in Turkish stock market and oil are asymptotically independent.

JEL: C46, C51, C53, F4

KEYWORDS: Bivariate EVT, Stock Market Returns, Oil Prices, ISE

INTRODUCTION

Scarce energy sources and world's growing demand for energy highlight the importance of energy economics. Oil is still the world's leading energy input considering nearly 35 percent of the global energy consumption provided by oil. This percentage is considerably more in the emerging industrialized nations. As it is explained in Basher and Sardosky (2006), emerging economies tend to be more energy intensive and are exposed to higher oil prices compared to developed countries that are more energy efficient in our day. Oil prices fluctuate unprecedentedly during the past decade, especially after 2003. Growing demand in emerging countries, invasion of Iraq, oil price speculations and global financial crises are the main reasons for past decade fluctuations. There is an increasing trend in the oil prices after 2003. Increasing prices have a considerable effect on macroeconomic variables such as growth rate, foreign trade balance and inflation particularly for emerging countries.

This study investigates dependence between oil prices and Turkish stock market. Turkey, as an emerging country, supplies more than 40 percent of its energy requirements from crude oil. About 9 percent of Turkey's total imports consist of crude oil. Considering importance of oil in Turkish economy, one can say that oil prices have a decisive effect on macroeconomic indicators. Despite various researches done on macroeconomics of energy matter, there is relatively limited number of researches, which concentrate on financial markets' reaction to the energy prices.

During the last decade, considerable amount of extreme price movements for oil and stock markets are observed. In the volatility of our times, extreme price movements become a familiar phenomenon. Oil and stock market relationship examined by the current literature mainly focused on analyzing central observations. This study concentrated on oil price and Turkish stock market relationship on the extreme events. This approach may help to understand the behavior of financial markets in volatile conditions and times of crisis. The rest of the paper continues as follows: Section 2 presents the literature review, Section 3 identifies the model and the data used for this study, Section 4 present the empirical results for the study and Section 5 concludes the paper.

LITERATURE REVIEW

Numerous researchers through the last two decades have studied oil price effect on macroeconomic variables. Hamilton's (1983) study can be considered as a starting point in the literature of this subject, followed by other researchers such as; Loungani (1986), Gisser and Goodwin (1986), Mork (1989). Considering the number of researches that have analyzed oil price effect, there is relatively small number of works that focused on the stock markets.

Going through the literature, many of the findings represent a negative relationship between oil prices and stock markets. Jones and Kaul's (1996) study was the first to reveal negative impact of oil prices on stock exchanges. Sadorsky (1999) and Papapetrou (2001) find a negative relationship between stock markets and oil prices. Sadorsky (1999) also reports a change in oil price dynamics, that after 1986 oil price explains a larger fraction of forecast error variance in stock returns. An increased number of researches can be observed after 2000's together with more diversified findings on oil and stock market relationship.

In the recent literature, some of the negative oil and stock market relationship findings continue as follows: Hammoudeh and Li (2005) reveal a negative bidirectional dynamic relationship between oil future price and Morgan Stanley Capital International (MSCI) global equity index. Park and Ratti (2008) apply multivariate vector auto regressive (VAR) analysis on US and 13 European countries stock indices and conclude that oil price shocks have a negative impact on real stock returns except for Norway, which is an oil exporter country. Bhar and Nikolova (2010) conduct bivariate exponential general autoregressive conditional heteroskedastic (GARCH) model on weekly data and identify a negative time varying conditional correlation between Russian equity market and oil price. Filis (2010) observes negative effect of oil price on Greek stock market by using a VAR approach. Lee and Chiou (2011) find a significant negative impact of oil prices on US stock returns.

Recent findings also show positive relationship between oil and stock markets. Constantinos et al. (2010) estimate a VAR model with granger causality tests on daily data and indicate a significant positive association between Greek stock market and oil prices. Choi and Hammoudeh (2010) employ Markow-switching GARCH models on oil price and US SP500 index and argue that high volatility regimes have positive probability correlations. Zhu et al. (2011) investigate on 14 countries and conclude that increased oil prices have a positive impact on stock prices and increased stocks influence crude oil positively. Narayan and Narayan (2010) conduct a long-run model on daily data and show that oil price and exchange rate have a significant positive effect on Vietnamese stock prices. Basher and Sadorsky (2006) also reveal that oil price risk on 21 emerging stock markets is statistically significant and positive in most models. A part of the literature suggests that there is a conditional relationship between oil and stock market or no relationship at all. Filis et al. (2011) employ dynamic conditional correlation GARCH (DCC-GARCH) model on monthly data of three oil importing and three oil exporting countries.

They assert that precautionary demand side oil shocks cause negative correlations whereas aggregate demand side shocks cause positive correlations. Their findings also show that oil price shocks during global business cycle fluctuations have a significant effect on oil price relationship regardless of countries oil dependence status, however oil shocks caused from production cuts do not seem to have an significant impact. Faff and Brailsford (1999) conduct augmented market model on 24 Australian industry portfolios and oil price. Their findings indicate a positive sensitivity for diversified industrial resources and oil and gas portfolios together with a negative sensitivity for transportation and paper and packaging portfolios. Eryigit (2009) applies Faff and Brailsford's (1999) augmented market model on 16 sector indices of

Istanbul Stock Exchange and demonstrate that different oil price effects for different indices. Malik and Hammoudeh (2007) estimate a multivariate GARCH model with BEKK parameterization on daily data and conclude that Gulf equity markets receive volatility from oil market. Mohanty et al. (2010) and Laopodis (2011) analyze European stock markets and reveal that there is no relation between equity and oil prices. Hearn and Man (2010) apply a VAR model on monthly data for China and Hong Kong stock indices and conclude that there is general lack of long-term price integration between markets and oil price. Maghyereh (2004) and Al-Fayoumi (2009) investigate on emerging market stock indices and document that oil price do not affect these stock markets. Hammoudeh and Choi (2006) estimate a VEC model on 5 Gulf Cooperation Council (GCC) countries stock markets and could not find a relationship between oil price and GCC equities. Huang et al. (1996) investigate US SP500 stock index on different levels by using a VAR approach. They provide that there is no relationship between oil futures and broad based stock index but on the firm level they discover a significant relationship.

Contribution of this study to the existing literature will be using bivariate extreme value theory for analyzing the dependence structure of stock market and oil prices. As it is mentioned in some of the studies such as: Choi and Hammoudeh (2010) and Lee and Chiou (2011), different volatility regimes have different oil price effect on stock markets. High volatility environment has many extreme events in term of oil price and stock market movements, which also illustrates our global market structure in the last decade. Instead of the normal price behavior of crude oil, this study will focus on extremal events by using a bivariate extreme value methodology on an emerging market, Turkey.

METHODOLOGY

Data

In this study, daily data is used for crude oil prices and stock market index. The daily data covers the period from January 1988 to August 2011. Brent oil prices are used as the crude oil prices since Brent oil index is the main indicator for Turkish oil trade. Oil price data come from U.S. Energy Information Administration (EIA). Istanbul Stock Exchange 100 (ISE 100) closing prices are used as the stock market data. Stock market data is taken from Istanbul Stock Exchange web site (www.ise.org). Both oil and stock prices are expressed in US dollars. Our data set consists of log returns of spot prices and there is a total of 5732 observation excluding missing days for oil price and stock index. Considering the chronological events of late 1990s and 2000s such as; (1998) Asian economic crisis, (2001) 9/11 attacks, (2003) Iraq war and 2007 Subprime crisis, we divide our dataset into two phases. The first phase covers the years 1988-1999 and the second phase covers the years through 2000-2011. The data covers a period of 23 years during which we observe a shift in scale of prices and volatility both in oil and stock market.

Descriptive statistic results provided in Table 1 demonstrate ISE 100 index returns are more volatile compared to oil returns. Results of the Jarque-Bera test shows that oil returns and ISE 100 index returns are not normally distributed at both phases. Skewness and excess kurtosis values also indicate the same result. Augmented Dickey-Fuller (ADF) test shows us that our data set at both phases are stationary. Data set used in this study is not independent and identically distributed (i.i.d.) except for oil returns at the second phase according to Ljung-Box test statistics. To test data with bivariate extreme value model, data set needs to be converted into i.i.d. series. We utilized an ARIMA model for data conversion process. Data set is examined according to Akaike information criteria (AIC) and Bayesian information criteria (BIC) to get the best-fitted model possible. Tools for selecting AIC and BIC values are provided in Hyndman’s (2011) package ‘forecast’.

Table 1: Descriptive Statistics

Statistics	Phase 1		Phase 2	
	Brent	ISE 100	Brent	ISE 100
Mean	0.0001	0.0002	0.0006	0.0003
Median	0.0000	-0.0002	0.0014	0.0008
Maximum	0.1733	0.1774	0.1813	0.2500
Minimum	-0.3612	-0.2538	-1.1989	-0.2367
Std. Dev	0.0238	0.0330	0.0249	0.0313
Skewness	-1.113	-0.3979	-0.3594	0.0169
Kurtosis	27.653	7.450	8.311	10.421
Jarque-Bera	73,167***	2,440.7***	3,430.6***	6,575.7***
Augmented Dickey-Fuller	-12.686***	-12.727***	-12.756***	-11.795***
Ljung-Box *[p-value]*	6.714*** *[0.0096]*	66.391*** *[0.0000]*	0.751 *[0.3862]*	16.662*** *[0.0000]*
Observations	2866	2866	2866	2866

*This table shows descriptive statistics for Brent oil log-returns and ISE 100 index log-returns for the two phases. Phase 1 and phase 2 cover the periods from 1988 to 1999 and from 2000 to 2011, respectively. In each phase 2866 daily observations are used, as the extreme value methodology requires high frequency data. ***, **, * Denote significance at the 1%, 5%, and 10% levels, respectively.*

Statistical results for Ljung-Box tests and lag order of ARIMA models are represented in Table 2. Ljung-Box results indicate that data set is i.i.d. after fitting ARIMA models. Since oil returns at the second phase are already i.i.d. series, it is not necessary to fit the model for this series.

Table 2: ARIMA Models

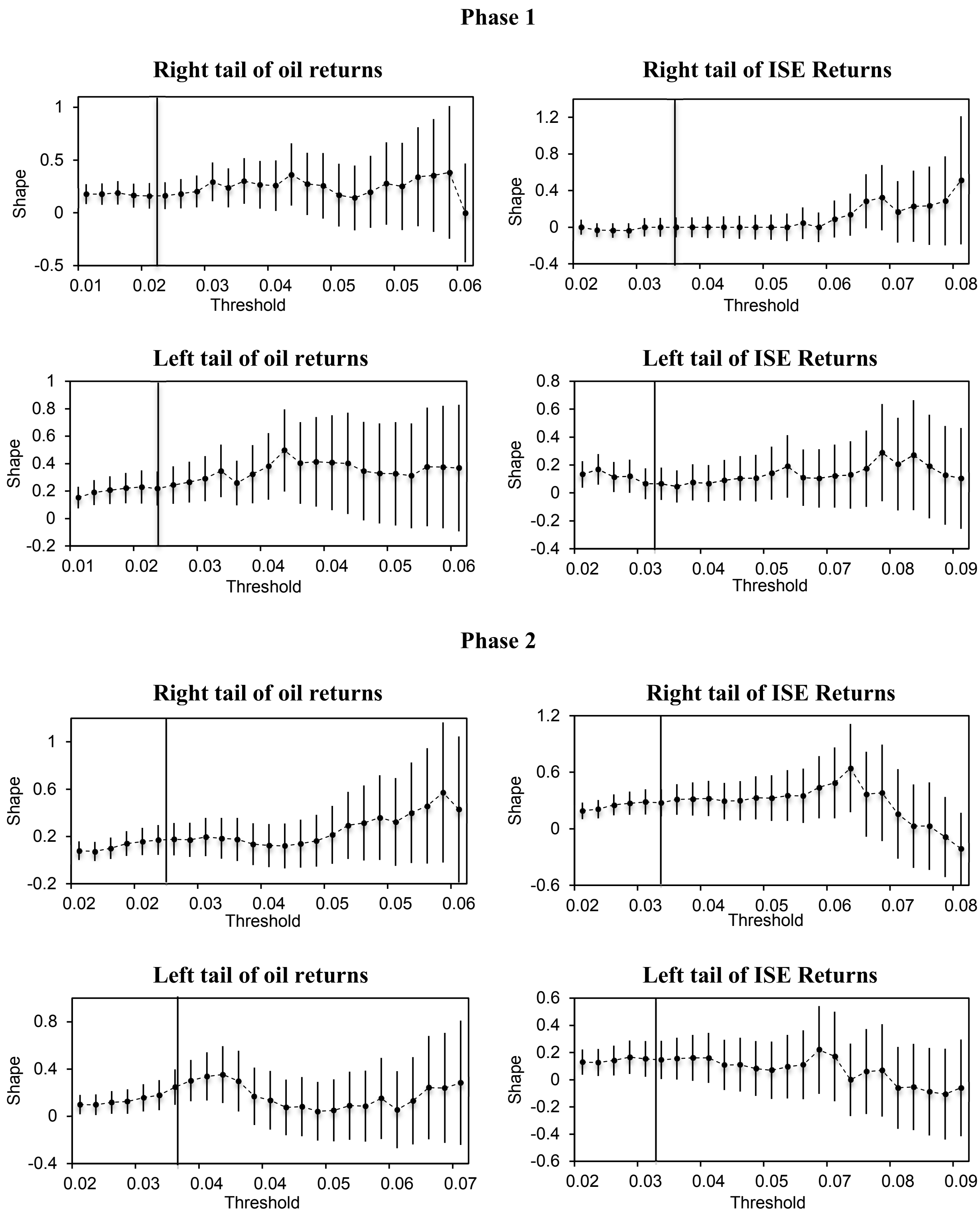
Statistics	Phase 1		Phase 2	
	Brent	ISE 100	Brent	ISE 100
ARIMA Model	ARIMA(1,0,4)	ARIMA(2,0,2)	ARIMA(0,0,0)	ARIMA(0,0,1)
Ljung-Box *[p-value]*	0.0012 [0.9718]	0.0010 [0.9742]	0.7507 *[0.3862]*	0.0071 [0.9329]

This table shows fitted ARIMA models and Ljung-Box statistics for oil log-returns and ISE 100 index log-returns for the two phases. Phase 1 and phase 2 cover the periods from 1988 to 1999 and from 2000 to 2011, respectively. In each phase 2866 daily observations are used, as the extreme value methodology requires high frequency data. Data set is examined according to AIC *and* BIC *criteria to get the best-fitted model possible. ***, **, * Denote significance at the 1%, 5%, and 10% levels, respectively.*

Model

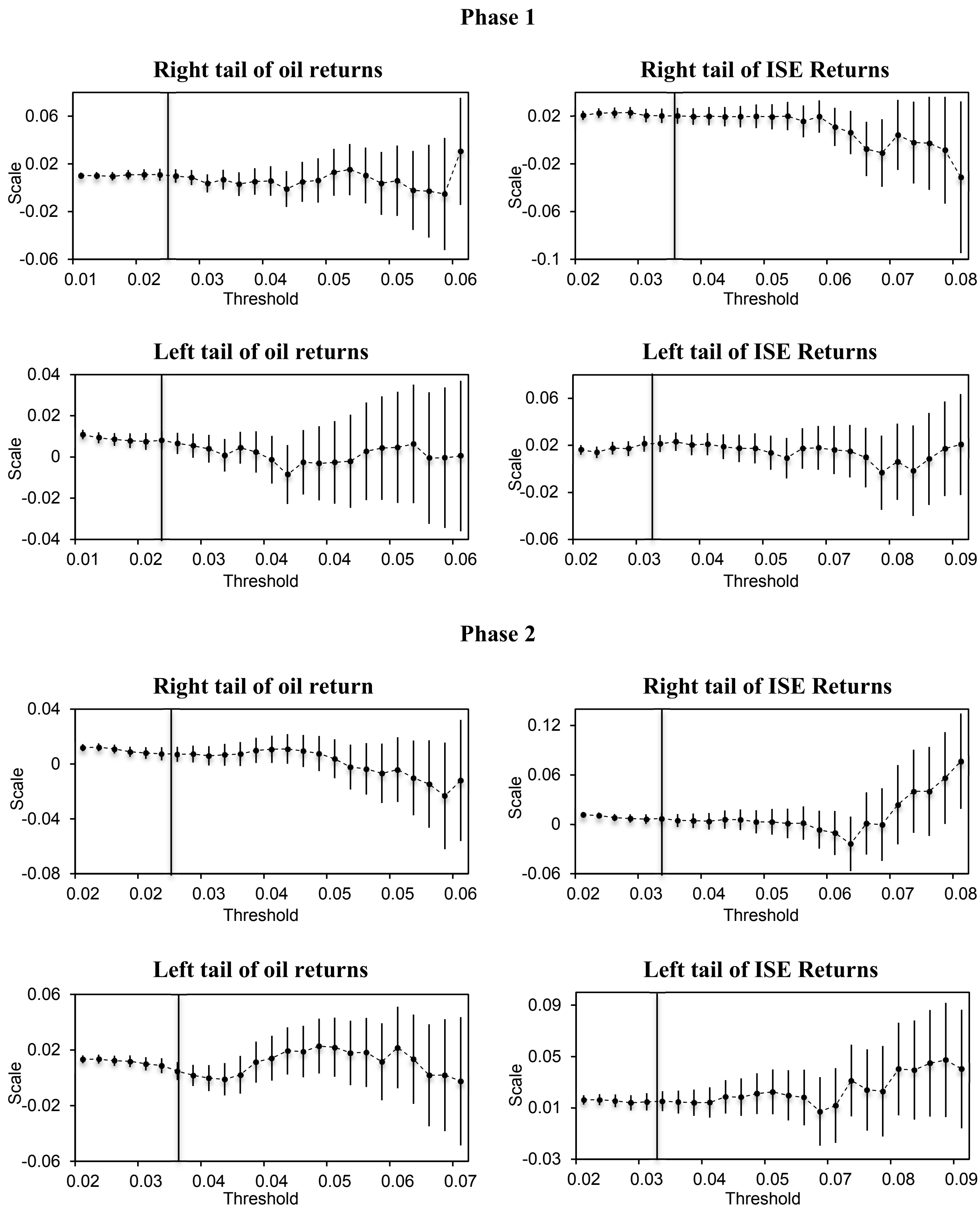
Bivariate extreme value methodology is used in this study to investigate the dependence between stock market and oil returns. Extreme value method is used to block extrema or exceedances to a predetermined threshold. Determining the threshold level is crucial for extreme value analysis. A low threshold level would cause selecting samples from central part of the distribution, while a high threshold level would eventuate with insufficient data and inaccurate estimates. Threshold level for our data series is determined as 10^{th} percentile for the lowest returns and 90^{th} percentile for the highest returns. Threshold levels are determined visually by using threshold choice plots and mean residual life plots provided in Figure 1, Figure 2 and Figure 3. The dependence strength between extreme returns of ISE and oil prices is estimated by fitting joint exceedances to a bivariate extreme value distribution. Censored likelihood methodology is used for this procedure, which is described in Ledford and Tawn's (1996) study.Dependence structure of extreme returns is computed by using logistic bivariate Generalized Pareto Distribution (GPD) model. This model is described in Mendes and Moretti (2002), Klüppelberg (2006) and Onay and Ünal (2011). Tools for computing logistic bivariate GPD model are provided in Ribatet's (2009) POT package. Summary of the model is presented below.

Figure 1. Threshold Choice Plots



The figure presents threshold choice plots for the left and right tails of oil returns and ISE 100 returns. The figure shows how the estimated shape parameter changes with different choices of thresholds. For each threshold level, the estimated parameter is plotted within a 95% confidence interval. The thresholds selected are marked with the longitudinal vertical lines. The estimated shape parameters are expected to be constant after the threshold selected.

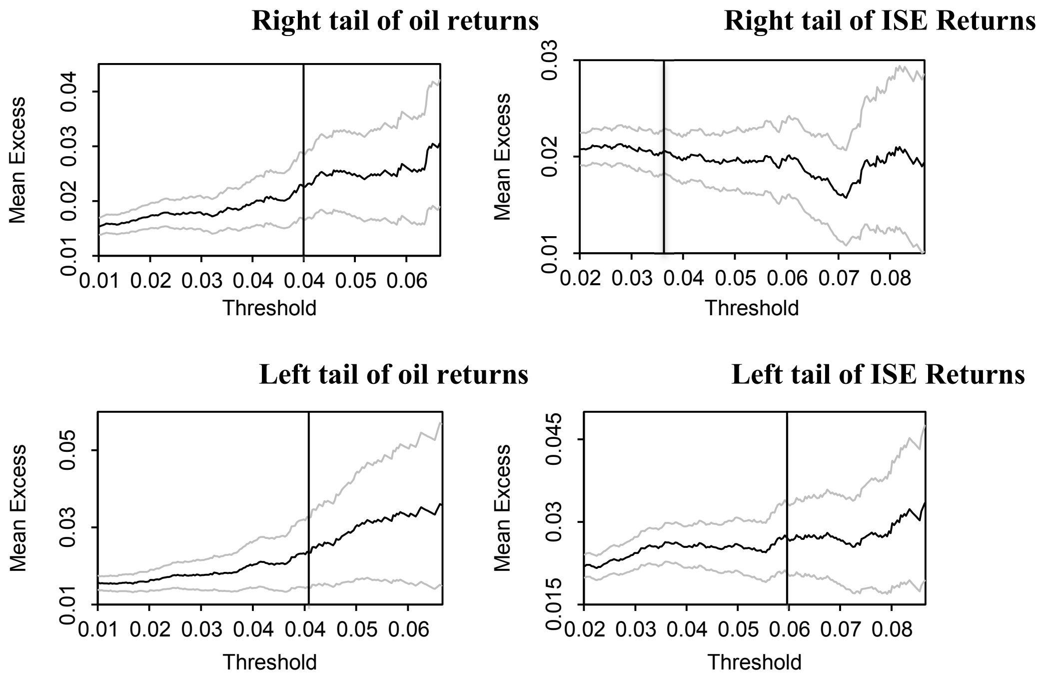
Figure 2. Threshold Choice Plots



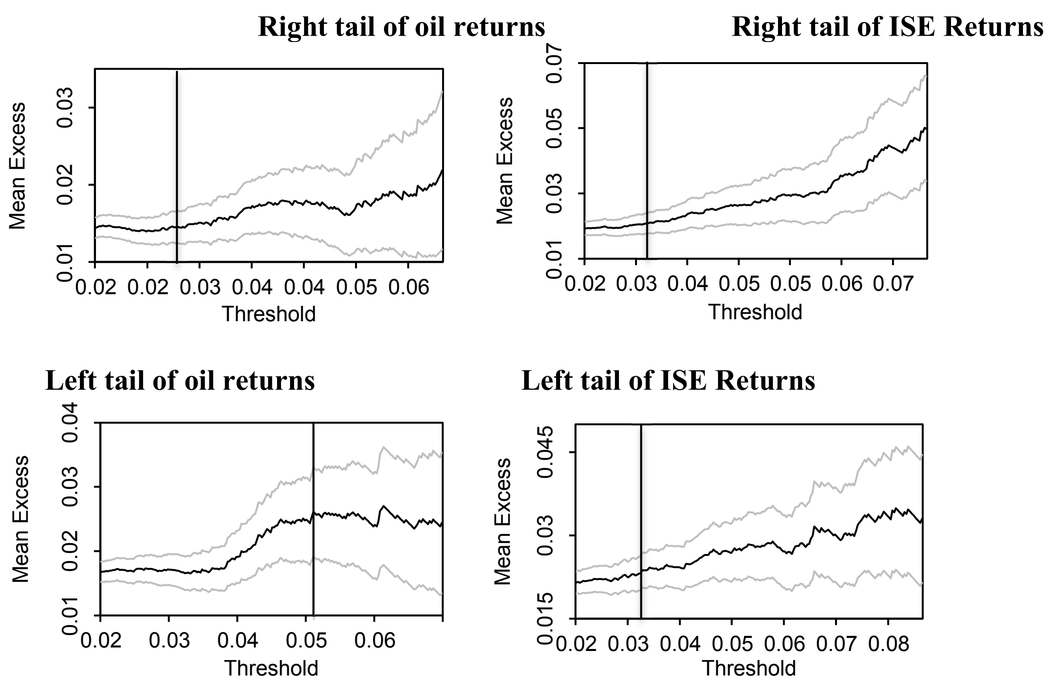
The figure presents threshold choice plots for the left and right tails of oil returns and ISE 100 returns. The figure shows how the estimated scale parameter changes with different choices of thresholds. For each threshold level, the estimated parameter is plotted within a 95% confidence interval. The thresholds selected are marked with the longitudinal vertical lines. The estimated scale parameters are expected to be constant after the threshold selected.

Figure 3. Mean Residual Life Plots

Phase 1



Phase 2



The figure represents Mean Residual Life plots for the left and right tails of oil returns and ISE 100 returns. The figure shows how mean value of exceedances over the threshold changes with different choices of thresholds. For each threshold level, the estimated mean residual life value is plotted within a 95% confidence interval. The thresholds selected are marked with the longitudinal vertical lines. The mean excess values against threshold levels are expected to be linear after an appropriate threshold level.

Following dependence function defines the logistic model:

$$A:[0,1]\rightarrow[0,1], \quad w\mapsto\left\{(1-w)^{1/\alpha}+w^{1/\alpha}\right\}^{\alpha} \tag{1}$$

where $0<\alpha\leq 1$. This gives the joint distribution function:

$$G(x,y)=e^{-V(x,y)}=e^{-\left(x^{-1/\alpha}+y^{-1/\alpha}\right)^{\alpha}} \tag{3}$$

for x, y > 0. Complete dependence is obtained when $\alpha\rightarrow 0$ and total independence is when $\alpha = 1$.Dependence of extreme returns between oil and ISE 100 index is identified by the χ(Chi) statistic of Coles et al. (1999) work.

$$\chi=2-V(1,1)=2(1-A(0.5)) \tag{3}$$

Perfect dependence is denoted by χ-statistic getting closer to 1 and independent variables denoted by χ -statistic getting closer to 0.

EMPIRICAL RESULT

Threshold levels of 10th and 90th quantiles of oil returns and ISE 100 returns indicates there are 287 highest and 287 lowest extreme events exceeding selected thresholds out of 2865 daily returns for each phase. The corresponding quantiles, taken as thresholds for the analysis of extreme ISE returns, are -3.41% for the left tail and 3.71% for the right tail in the first phase. In the second phase, the thresholds are -3.29% and 3.21% for the left and right tails, respectively. For Brent returns, 10th and 90th quantiles are 2.38% and 2.29% in the first phase and -2.88% and 2.75% in the second period. For example, if there is a daily loss greater than 3.41% in the first phase studied, the observation is considered to exceed the threshold and is incorporated in the estimation of the GPD model for the left tail. Similarly, if there is a daily return higher than 3.71% in the first phase, the observation is included in the estimation of the model for the right tail. Table 3 shows bivariate EVT model results for ISE100 and Brent oil extreme returns. Independence assumption suggests that 28.6 events coincide on the same day at 10th and 90th quantiles. Between 1988 and 1999, our results show that 30 of the 287 highest returns and 31 of the lowest 287 returns happen on the same day. However, between 2000 and 2011, higher numbers of joint exceedances occurred, as 45 highest returns and 55 lowest returns happen on the same day. In other words, there are 55 days when ISE lost more than 3.29% and Brent oil lost more than 2.88% concurrently.

Table 3 also shows us figures for computing conditional probabilities to investigate oil price latency effect to stock markets by setting a 3-day margin. Under total independence assumption, for each consecutive day 28.6 extreme observations, or a total of 85.8 extreme observations over the next three days is expected. This study shows that 92 of the 287 highest returns (32%) and 85 of the lowest 287 returns (30%) happen within the 3 days at the first phase, while 118 of the 287 highest returns (41%) and 130 of the lowest 287 returns (45%) happens within the 3 days at the second phase respectively. The numbers in parentheses imply conditional probabilities of having an extreme daily stock market return in the coming next three days when today is an extreme day for oil returns. Given that oil loses more than 2.88% one day in the second subperiod, there is 45% probability that in the next three days ISE experiences a daily loss greater than 3.29%.

Table 4 shows the estimated parameters and their standard errors of the GPD models that are fit to our exceedance data over selected thresholds. Except for the second shape parameters for right and left tails in the phase 1, all estimated parameters are significant. The alpha parameters of all four models estimated (for both sub periods and for both right and left tails) are close to one, which imply independence in extreme observations. These results are in line with chi-statistic values reported in Table 3, which also imply independence with close to zero values.

Table 3: Bivariate Extreme Model Results for ISE100 and Brent Returns

	Phase 1 (1988 -1999)		**Phase 2 (1999 - 2011)**	
	Right Tail	Left Tail	Right Tail	Left Tail
Chi-Statistic	0.017	0.008	0.06	0.103
Deviance	331	412	196	344
Marginal Number Above	287	287	287	287
Joint Number Above	30	31	45	55
Joint Number Above (3days)	92	85	118	130

This table shows the results of the bivariate extreme value models forecasted for Brent oil and ISE 100 extreme returns. The right and the left tail models show results for extreme high returns and extreme high losses returns at 90^{th} quantile respectively. The analysis is carried for two subperiods, where phase 1 corresponds to the period between 1988 and 1999 and phase 2 to the period between 2000 and 2011.

Table 4: Bivariate Extreme Model Estimates for ISE100 and Brent Returns

	Phase 1 (1988 - 1999)				Phase 2 (1999 - 2011)			
	Right Tail		Left Tail		Right Tail		Left Tail	
Scale1	0.0153	(0.0013)	0.0131	(0.0011)	0.0123	(0.0011)	0.0140	(0.0012)
Shape1	0.1401	(0.0606)	0.2253	(0.0637)	0.1701	(0.0672)	0.1944	(0.0662)
Scale2	0.0212	(0.0016)	0.0242	(0.0020)	0.0152	(0.0014)	0.0204	(0.0018)
Shape2	-0.0238	(0.0499)	0.0548	(0.0557)	0.3026	(0.0755)	0.1462	(0.0686)
Alpha	0.9880	(0.0105)	0.9942	(0.0118)	0.9560	(0.0159)	0.9238	(0.0174)

This table shows the estimated parameters of the GPD models fit using bivariate data series ISE 100 and Brent oil returns at 90^{th} quantile. The numbers in parentheses gives standard errors of the estimated parameters. The analysis is carried for two subperiods, where phase 1 corresponds to 1998 and 1999 and phase 2 to the period between 2000 and 2011.

In general, it is not possible to speak of a dependency relationship between oil and ISE index. Bivariate extreme dependence analysis indicates that oil and ISE 100 returns have higher dependence at the second phase, in the years from 2000 to 2011. Joint number of days exceeding selected thresholds at second phase is increased by 50 percent for the positive tail and by 77 percent for the negative tail compared to the first phase. Chi-statistics at the second phase is 3.5 times greater for the positive tail and 12.9 times greater for the negative tail, compared to the first phase. In the light of model results, increase in the oil and ISE 100 returns extreme dependence during the second phase is clearly mentioned. Negative returns for oil and ISE 100 index have higher dependence value compared to the positive returns at the second phase. It is possible to refer that negative oil price movements affect ISE 100 index more commonly compared to positive movements at the second phase.

CONCLUSION

This paper examines extreme dependence between oil prices and the Turkish stock index. The data used for dependence analysis consist of daily log returns on Brent oil prices and ISE 100 index for the period between 1988 and 2011. Turkey supplies nearly half of its energy requirement from crude oil. Oil is one of the major commodities for Turkey's total imports. Expanding emerging countries need oil as a source of energy for their growing industries. Their exposure to oil price fluctuations is directly compared to developed nations. The main motive of this study is to show an oil price effect on an oil dependent emerging country. Researches that investigate oil price and stock market relationship in the literature, mainly focus on analyzing central observations. This paper is first to study the dependency relationship of stock exchange and oil returns by exploring the extreme observations employing bivariate EVT models.

Results of this study reveal an asymptotic independence between oil prices and ISE 100 index returns in extreme observations. Bivariate extreme dependence analysis applied to the data set by dividing data into two phases, where phase 1 and phase 2 cover the periods from 1988 to 1999 and from 2000 to 2011. In the first phase studied, the chi-statistics are very close to zero (0.008 and 0.017 for the left and right tails respectively), implying no dependence at all. In the second phase, the extreme observations chi-statistics are somewhat higher but still very close to zero (0.103 and 0.060 for the left and right tails respectively). Extreme dependence analysis indicates that oil and ISE 100 returns have higher dependence at the second phase. It is also observed that negative oil price movements affect ISE 100 index more commonly compared to positive movements at the second phase. Oil price effect latency to stock markets is also examined within the study by setting a 3-day margin. Yet, the number of observed joint exceedances is quite close to the expected values under complete independence assumption.

Findings of this study, which indicates absence of extreme dependence between oil and stock markets, may help portfolio managers and investors identify better diversification opportunities. However, considering higher dependence of stock markets for negative oil price movements especially in the last decade, diversification opportunities must be used with caution in the times of crisis.

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BIOGRAPHY

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