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The Impact of Oil Price Shocks on Turkish Sovereign Yield Curve

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Abstract

This paper investigates the impact of oil price shocks on Turkish sovereign yield curve factors. The recent oil shock identification scheme of Ready (2018) is modified by using geopolitical oil price risk index in order to capture the changes in the risk perceptions of oil markets driven by geopolitical tensions such as terrorism, conflicts and sanctions. The modified identification scheme attributes more power to demand shocks in explaining the variation of the oil price. Furthermore, our findings demonstrate that the various oil price shocks influence the yield curve factors quite differently. A supply shock leads to a statistically significant increase in the level factor. This result shows that elevated oil prices due to supply disruptions are interpreted as a signal of surge in inflation expectations since the cost channel prevails. Moreover, unanticipated demand shocks have a positive impact on the slope factor as a result of the central bank policy response for offsetting the elevated inflation expectations. Overall, our results provide new insights to understand the driven forces of yield curve movements that are induced by various oil shocks in order to formulate appropriate policy responses.

Özet

Bu çalışma, petrol fiyatı şoklarının Türkiye'nin getiri eğrisi faktörleri üzerindeki etkisini incelemektedir. Yakın dönemde Ready (2018) tarafından önerilen petrol şoku tanımlama yöntemi, petrol piyasaları özelindeki risk algılamalarında terörizm, bölgesel çatışmalar ve yaptırımlar gibi jeopolitik gerilimlerin neden olduğu değişiklikleri yakalamak için jeopolitik petrol fiyatı risk endeksi kullanılarak değiştirilmiştir. Modifiye edilmiş yöntem, petrol fiyatındaki değişimi açıklamada talep şoklarına daha fazla açıklama gücü atfetmektedir. Ayrıca bulgularımız, çeşitli petrol fiyatı şoklarının getiri eğrisi faktörlerini oldukça farklı şekillerde etkilediğini göstermektedir. Arz şokları, seviye faktöründe istatistiksel olarak anlamlı bir artışa yol açmaktadır. Bu sonuç, arz kesintilerine bağlı olarak yükselen petrol fiyatlarının, maliyet kanalı baskın olduğundan enflasyon beklentilerinde bir artış sinyali olarak yorumlandığını göstermektedir. Ayrıca, beklenmeyen talep şoklarının eğim faktörü üzerinde, yükselen enflasyon beklentilerini dengelemek için merkez bankasının politika yanıtının bir sonucu olarak, pozitif bir etkisi bulunmaktadır. Sonuç olarak, bulgularımız uygun politika tepkilerini oluşturmak amacıyla çeşitli petrol şoklarının neden olduğu getiri eğrisi hareketlerinin itici güçlerini anlamak için yeni bilgiler sunmaktadır.

JEL classification: E43; E44; G12; G15; Q43

Keywords: Emerging markets; Local projections; Oil price; Supply and demand shocks; Yield curve factors; Geopolitical oil price risks

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Non-Technical Summary

As an oil-importer emerging market, the Turkish economy is subject to a high exposure to oil-price volatilities considering its macroeconomic structure. Energy imports constitute significant shares of total imports in recent decades which put a considerable burden on the current account. Besides, political instabilities in oil-rich countries keep the oil price-related risks alive. Over the recent decade, there have been several incidents in the region that led oil prices to fluctuate significantly. Some examples for these events include the recent drone attacks to Saudi Aramco that almost halved the country's oil production for several days, ongoing tensions between Iran and the US since the withdrawal of the US from the nuclear deal with Iran, the civil war in Yemen that lasts since 2015, sanctions to Iran in 2012, Syrian civil war and Libyan crisis since 2011, turbulence in several countries in the region named as the Arab spring in the 2010s, and the everlasting instabilities in Iraq since the US invasion. Considering that the conflicts and ongoing tensions between the countries in the region are still building new geopolitical risks for the oil market, the Turkish economy represents a suitable case study to investigate the impact of oil price dynamics on macroeconomic conditions.

In order to decipher the impact of changes in oil prices on Turkish sovereign yield curve, it is important to know the reason behind the movement in oil prices. Ready (2018) develops a framework to identify the demand and supply shocks via structural vector auto-regressions (SVAR) with sign restrictions by using information in asset prices. This method defines demand shocks as the part of the global oil-producing firm index returns being orthogonal to unexpected changes in risk appetite, whereas supply shocks are isolated as the part of oil price changes being independent of demand shocks and risk appetite.

The empirical analysis in this paper innovates the existing literature on twofold. Firstly, we modify the identification of Ready (2018) by incorporating the geopolitical oil price risks as it is more relevant to oil-importer emerging markets. Secondly, this paper is the first attempt to document the divergent impact of oil demand and supply shocks on Turkish sovereign yield curve factors. Overall, our findings demonstrate that the various oil price shocks influence the yield curve factors quite differently. Hence, it is important to understand the driven forces of yield curve movements that are induced by various oil shocks in order to formulate appropriate policy responses.

1. Introduction

The price movement in global oil markets has long been considered as a major determinant of macroeconomic aggregates since the seminal work of Hamilton (1983). Overwhelming evidence from earlier literature focuses on the negative impact of oil price rises on GDP growth. Energy price shocks are regarded to shape the aggregate economic activity through extenuating consumer and business spending (Hamilton (2008)). Furthermore, higher energy costs can reduce household disposable income restricting the consumption expenditures. Oil prices have also include predictive information for the inflation and formation of inflation expectation (Harris et al. (2009)). However, succeeding studies aim to identify the varied impact of oil prices given the exporter/importer status of countries. While sharp increases in oil prices contribute to the macroeconomic performance of oil-exporting countries by improving national income and fiscal balance (given the low price elasticity of oil demand), they can overturn oil-importing countries by boosting inflation, limiting growth rates, reducing the expenditures on non-oil goods, adversely affecting current account balance and hiking costs with inflation pressures (Kilian and Lewis (2011), Jung and Park (2011) Naser (2016)).

As an oil-importer emerging market, the Turkish economy is also subject to significant exposure to oil-price volatilities considering the macroeconomic structure. Energy imports constitute significant shares of total imports in recent decades which put a considerable burden on the current account[1]. Historically speaking, the portion of energy use covered by importation has an increasing trend, whereas crude oil and petroleum product imports have been elevated in nominal terms[2]. Apart from its role on growth and foreign trade balance, due to the composition of industrial production, any shock originated in global oil prices invokes production costs which are ultimately transmitted to consumer prices in the form of inflationary pressures (Ogunc et al. (2018))[3].

Over the recent decade, there have been several incidents in the region that led oil prices to fluctuate significantly. Some examples for these events include the recent drone attacks to Saudi Aramco that almost halved the country's oil production for several days, ongoing tensions between Iran and the US since the

[1] Turkey is one of the highest energy-dependent countries among the OECD countries. Statistics published by International Energy Agency indicate that, by 2017, Turkey ranks as eight-country among 36 OECD members that have the highest net energy imports over energy usage.

[2] See the Figure A1 of the appendix

[3] As seen in Figure A2 of the appendix, upward movements in oil prices generally coincided with the inflationary tendencies.

withdrawal of the US from the nuclear deal with Iran, the civil war in Yemen that lasts since 2015, sanctions to Iran in 2012, Syrian civil war and Libyan crisis since 2011, turbulence in several countries in the region named as the Arab spring in the 2010s, and the everlasting instabilities in Iraq since the US invasion. Considering that the conflicts and ongoing tensions between the countries in the region are still building new geopolitical risks for the oil market, the Turkish economy represents a suitable case study to investigate the impact of oil price dynamics on macroeconomic conditions.

A closer strand of literature is devoted to evaluating the influence on financial variables in addition to the macroeconomic aggregates to help better illuminate the link between the oil market and broader economic dynamics. However, it has been mostly limited to equity markets reflecting the negative response of stock returns on oil price increases in oil-importing countries (Basher et al. (2018), Elder and Serletis (2010), Kilian and Park (2009)). In contrast to this view, other studies argue that the stock market response is heterogeneous across industries, especially in the post-crisis period, as energy-intensive manufacturing firms' stock prices respond more heavily to onset oil price fluctuations (Tsai (2015)). In the case of energy producers, escalation in oil prices tends to boost potential future revenues and firm growth so stock market valuations are expected to go up. Moya-Martinez et al. (2014) conclude that oil price shocks tend to improve the industrial stock returns of Spanish companies in the recent period. Furthermore, financial variables are shown to provide predictive power for forecasting oil prices. By using factor-augmented VAR (FAVAR) models, Zagaglia (2010) show that latent factors correlated with purely financial phenomena improve the forecasting performance.

Having more relevance to this paper, few studies in the literature deals with the bond market instead of the stock market in investigating the association of oil price shocks to financial indicators. To exemplify, Kang et al. (2014) examine the effect of oil shocks on aggregate US bond index returns. They find that market-specific demand shock causes decreases in bond index returns over two-year horizon. Although most studies preferred to focus on short-term rates to assess the contribution of monetary policy responses to oil price movements; Ioannidis and Ka (2018) evaluate the oil price shocks and their role in term-structure components by fitting entire yield curve instead of using bond indices. In the case of Turkey, as stock markets are not developed extensively, bond markets being dominated by sovereign instruments are thought to reflect the financial pricing of global and macroeconomic events including oil market developments. From another perspective, disentangling yield curve components is informative for assessing the propagation of oil price shocks through macroeconomic channels as recent studies display the close relation between "yield curve factors" and "growth, inflation, global forces", as documented by Cepni et al. (2018). Hence, in this paper, we choose to focus on the sovereign bond market to identify the financial response of oil shocks.

Regardless of the macroeconomic or financial response, an important stage in the literature has been achieved with the argument that supply and demand forces in the creation of oil prices have different effects. In other words, depending on whether the supply or demand side is responsible for the origination of shock, the impact on financial markets and the economy will differ (Hamilton (2008)). Kilian (2009) prove that oil-market specific demand shocks actually diminish growth simultaneously and raise inflation, whereas oil shocks created by aggregate global demand decrease the growth performance with delays. Kilian (2009) also document that supply shocks cause a temporary setback in GDP growth with no significant results on inflation. Using data from 16 countries for the period between 1999 and 2011, Liu et al. (2016) show that the magnitude and duration of stock market response to oil price shocks are subject to the driving force of oil price changes. Baumeister and Peersman (2013) oil price hikes stimulated by favorable global growth conditions exert effects on the US economy completely different from the one caused by supply disruptions due to geopolitical events. Ready (2018) also attempt to explain the asymmetric results from supply/demand forces. It is argued that if oil prices go up because of the higher oil demand, then producer firms can increase the quantity sold to obtain positive returns. However, if supply shocks are effective and (as a commodity) oil becomes infeasible to produce, then the impact on the firm value and economic growth is unclear given the conflicting relation between higher prices and lower quantity sold. Similar asymmetries are also mentioned in studies investigating financial variables. Ioannidis and Ka (2018) find that demand shocks have positive consequences on the level factor of the yield curve in oil-importing countries, while supply disruptions have a negative manifestation in slope components associated with monetary policy loosening. Moreover, demand-side-originated disturbances tend to cause increases in slope components.

On the methodological side, an earlier approach to separate demand and supply shocks in the oil market is pursued by studies like Hamilton (1983) and Hamilton (2003) aim to determine instruments for oil price changes being exogenous to other economic forces such as time series of events causing supply disruptions. However, this approach is criticized as it is hard to embody consistent instruments to clearly identify supply shocks such as war or natural disasters. An alternative approach is developed by Kilian (2009) to identify the demand and supply shocks via structural vector autoregressions (SVAR) with sign restrictions by using data on oil production and shipping prices. Oil supply shocks are identified as innovations to global oil production which are assumed to insensitive to demand contemporaneously. Innovations to global economic activity that cannot be explained by oil supply shocks are termed as aggregate demand shocks. On the other hand, innovations to oil prices left out by other types of disturbances are named as oil-specific demand shocks. Kilian and Park (2009) extends this framework by decomposing oil price changes into demand, supply, and precautionary demand shocks which represent the unexplained portion of the variability. Precautionary demand is initiated by the uncertainty about the expected inadequacy of future supply relative to future demand. However, this approach is also subject to criticisms as data included in SVAR need to have co-movement with future changes in oil prices to define the shocks appropriately. It is also ascertained that it is impossible to know that to what extent precautionary demand is composed of supply or demand expectations. Being more suitable to financial variables, in this paper, we utilize the method of Ready (2018) with minor alterations. This method defines demand shocks as the part of the global oil-producing firm index returns being orthogonal to unexpected changes in risk appetite, whereas supply shocks are isolated as the part of oil price changes being independent of demand shocks and risk appetite. Empirical evidence provided by Ready (2018) show that shock decomposition in this method is consistent with theoretical expectations intuitively as price increases caused by supply shocks are negatively correlated with oil production and economic growth, whereas price increases initiated by demand disturbances are associated with increased oil production and economic growth.

The empirical analysis in this paper innovates the existing literature on twofold. Firstly, it is the first attempt to document the divergent impact of demand and supply oil shocks on Turkish bond yields. Secondly, we aim to improve the identification of oil shocks by incorporating the geopolitical oil price risks as it is more relevant to oil-importer emerging markets.

The rest of the paper is structured as follows. Section 2 provides details about utilized data sets. Section 3 describes Nelson-Siegel and SVAR methodologies to create yield curve and oil shocks components. The same section also describes DCC-GARCH(1,1) and local projections methods to evaluate the static and dynamic associations between yield curve factors and oil shocks. Section 4 discusses empirical results, while the last section gives concluding remarks.

2. Data

We collect monthly zero-coupon yields of Turkish sovereign bonds with maturities 3, 6, 12, 24, 36, 48, 60, 72, 84, 96, 108 and 120 months to estimate the yield curve factors. The zero-coupon bond yields are downloaded from the Bloomberg terminal. Our sample covers the period of April 2005 - December

2019. As in Ready (2018), monthly returns on the Word Integrated Oil and Gas Producers Index are available from Datastream. Similarly, the closest expiry NYMEX WTI crude oil futures contract at month-end is used and is obtained from the U.S. Energy Information Administration. Monthly data on geopolitical oil price risk (GOPR) index is based on the work of Bonaparte (2019)[4]. This index uses Google Trends data to obtain search volume for keyword phrases commonly related to politics, uncertainty, oil price and supply. In particular, they consider 27 different worldwide search terms to track the patterns precisely for a comprehensive information about geopolitical oil price risk.[5] They utilize a proprietary application of factor analysis to create the monthly index and normalize the GOPR index to between 0 and 100, in which 100 shows maximum geopolitical risk. In the Figure A4 of the appendix, we present the GOPR index and highlight the important events.

3. Methodology

3.1. Extraction of the yield curve factors

The conventional Nelson and Siegel (1987) model (NS) for zero-coupon yield curve has the following functional form:

$$y_t(\tau) = \beta_1 + \beta_2 \left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau} \right) + \beta_3 \left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau} \right), \qquad t = 1, \ldots, T \text{ and } \tau = 1, \ldots, N \tag{1}$$

where $y_t(\tau)$ represents the continuously-compounded zero-coupon nominal yield at time t of a bond with maturity τ and β_1, β_2, and β_3 are yield curve factors with loadings of 1, $\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right)$ and $\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right)$ respectively. Diebold and Li (2006) interpret the NS parameters as the level (β_1), slope (β_2) and curvature (β_3). The coefficient λ is interpreted as the shape parameter which induces both the steepness of the slope factor and the location of the hump as suggested by Annaert et al. (2013). We estimate the latent yield curve factors using non-linear least squares where the objective function is to minimize the squared difference between duration-inverse weighted actual and fitted prices[6].

[4]Data can be downloaded from the webpage:https://business.ucdenver.edu/commodities/applied-research/geopolitical-oil-price-risk-index-goprx

[5]The full list of keywords is given in Figure A3 of the appendix.

[6]The non-linear least-squares optimization may leads to a non-smooth parameter estimates especially for slope and curvature parameters. Thus, yield curve parameters are estimated with Ordinary Least Squares (OLS) via fixing λ to lower the variance of these parameters as suggested by Diebold and Li (2006). We implement a grid analysis to identify the optimal parameter λ providing the smallest root average squared error.

3.2. Identifying oil shocks with structural VAR methodology

Following the methodology of Ready (2018), we use monthly returns on the Word Integrated Oil and Gas Producers Index for a proxy for oil production R_t^{Prod}. For changes in oil price, the 1 -month returns Δp_t on the closest expiry NYMEX WTI crude oil futures contract at month end are utilized. Finally, although Ready (2018) uses innovations to VIX index as a proxy for discount factor shocks in the equity market, we propose a new modified identification scheme that substitutes the innovations of VIX with the innovations of the GOPR index. By construction, the GOPR index provides a signal for changes in risk in the oil markets driven by geopolitical tensions such as terrorism, conflicts and sanctions. Furthermore, Carney (2016) classifies the geopolitical risks as 'uncertainty trinity' along with economic and policy uncertainty that would have had negative economic consequences.

Defining $X_t = \begin{bmatrix} \Delta p_t & R_t^{\text{Prod}} & \xi_{\text{GOPR},t} \end{bmatrix}'$, a structural VAR model is employed to disentangle the supply shocks s_t, demand shocks d_t, and risk shocks r_t and is defined as:

$$X_t = C + \sum_{i=1}^{P} \Phi_i X_{t-i} + AZ_t \tag{2}$$

$$Z_t = \begin{bmatrix} r_t \\ d_t \\ s_t \end{bmatrix}, \quad A = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{12} & a_{22} & 0 \\ 1 & 1 & 1 \end{bmatrix}, \quad \text{Var}(Z_t) = \begin{bmatrix} \sigma_m^2 & 0 & 0 \\ 0 & \sigma_d^2 & 0 \\ 0 & 0 & \sigma_s^2 \end{bmatrix} \tag{3}$$

where r_t, d_t, and s_t represent risk shocks, demand shocks and supply shocks respectively. Furthermore, the shocks are normalised to sum up to the total change in oil prices. The volatilities of the identified shocks are denoted as σ_r, σ_d, σ_s. Orthogonality conditions are imposed on the matrix A to relate the identified shocks with the observable variables. Finally, the lag length P=1 is selected by BIC criteria.

3.3. Assessing the historical co-movements between yield curve factors and oil shocks with dynamic conditional correlation

After separating different sources of oil price shocks, we implement dynamic conditional correlation (DCC) analysis to uncover the historical co-movements between yield curve factors and shocks originated in oil markets before making any causal inferences. Considering the fact that global oil market dynamics as well as local financial conditions have been shaped by series of events over the course of sample period, it would be restrictive to assume that static coherence measures can capture the relationship of interest.

Thus, as an alternative methodology, we utilized the bivariate version of DCC-GARCH model proposed by Engle (2002) to derive time-varying correlation processes. This family of volatility models is vastly preferred in financial economics to isolate transmissions and interdependencies subject to variation over time (Bauwens et al. (2006) and Li et al. (2012)). As discussed in Naser (2016), regression-based methods turn out to be unsuccessful in tracking the time-varying nature of oil-price dynamics considering possible dynamic volatility formations, structural breaks and parameter instabilities. Thus, we prefer to proceed with DCC-type framework in our empirical strategy.

In this context, our empirical approach is structured in two steps. In the first step, we model the mean equation with AR(1) structure involving the vector of dependent variables including yield curve factors and oil price shocks in bivariate combinations. Mean equation estimation of DCC-GARCH model for the generalized case can be represented as follows:

$$r_t = \mu + \varphi r_{t-1} + \varepsilon_t \tag{4}$$

where $r_t = [r_{1,t}, \ldots, r_{n,t}]'$ stand for time series of the n variables. In the second step, conditional variances are being structured in the form of GARCH(1,1) as follows:

$$h_{i,t} = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{i,t-1} \tag{5}$$

Furthermore, conditional variance-covariance matrix for the generalized case can be specified as the following representation:

$$\begin{aligned} &E_{t-1}[\varepsilon_t] = 0 \\ &E_{t-1}[\varepsilon_t\varepsilon_t'] = H_t \\ &H_t = D_t^{1/2} R_t D_t^{1/2} \end{aligned} \tag{6}$$

Here, $E_t[\cdot]$ describes the conditioning on the information set available up to period t, whereas $R_t = \left[\rho_{ij,t}\right]$ is the conditional correlation matrix among examined series. On the other hand, conditional variances are demonstrated with the $D_t = \text{diag}\,(h_{1,t}, \ldots, h_{n,t})$. Engle (2002) provide formulation of the variance-covariance matrix as follows:

$$\begin{aligned} R_t &= \{Q_t^*\}^{-1/2}\, Q_t\, \{Q_t^*\}^{-1/2} \\ Q_t^* &= \text{diag}\,[Q_t] \\ Q_t = \left[q_{ij,t}\right] &= (1 - a - b)S + a u_{t-1}u_{t-1}' + bQ_{t-1} \end{aligned} \tag{7}$$

In this specification, $u_{i,t} = \frac{\varepsilon_{i,t}}{h_{i,t}}$ stand for standardized error terms, while $S = E\left[u_t u_t'\right]$ is n×n unconditional covariance matrix, a and b are non-negative scalar values. Each element of conditional correlation matrix can be generalized as:

$$\rho_{ij,t} = \frac{\rho_{ij,t}}{\sqrt{\rho_{ii,t}\rho_{jj,t}}}, \forall i, j = 1, 2, \ldots, n \text{ where } i \neq j \tag{8}$$

We estimate the same model structure six times for all bivariate combinations of yield curve factors (level, slope, curvature) and oil-price shocks (risk, demand, supply) to compose time-varying correlations.

3.4. Estimating impulse response functions using local projections

In his seminal paper, Jorda (2005) proposed an alternative approach to estimate impulse responses which is called Local projections (LPs). This method has many advantages over the standard VAR methods since it allows estimating responses on a variable-by-variable basis and also reduces the dependence of the impulse response functions on the specification of the data generation process. The great advantage of LPs is their flexible application in cases where an exogenous shock can be identified outside of an SVAR framework which applies to our case. Put differently, upon the identification of exogenous shocks, impulse responses can be directly estimated using the following specification:

$$y_{t+h} = \alpha_h + \sum_{k=0}^{m} \beta_{k,h} \text{oilshocks}_{t-k}^{j} + e_{t+h} \tag{9}$$

where y_t is alternatively, level, slope, and curvature; j= supply shocks, demand shocks and risk shocks; $t = 1, 2, \ldots, T$ is the time subscript; $k = 0, \ldots, m$, are the lags of oil shocks; e_t is an error term and finally h is the horizon of the local projections[7]. The coefficient $\beta_{k,h}$ represents to the response of y at time t + h to the shock variable (shock) at time t. Hence, the impulse responses are the sequence of all estimated $\beta_{k,h}$. We use heteroscedasticity and autocorrelation robust standard errors of Newey and West (1987) .

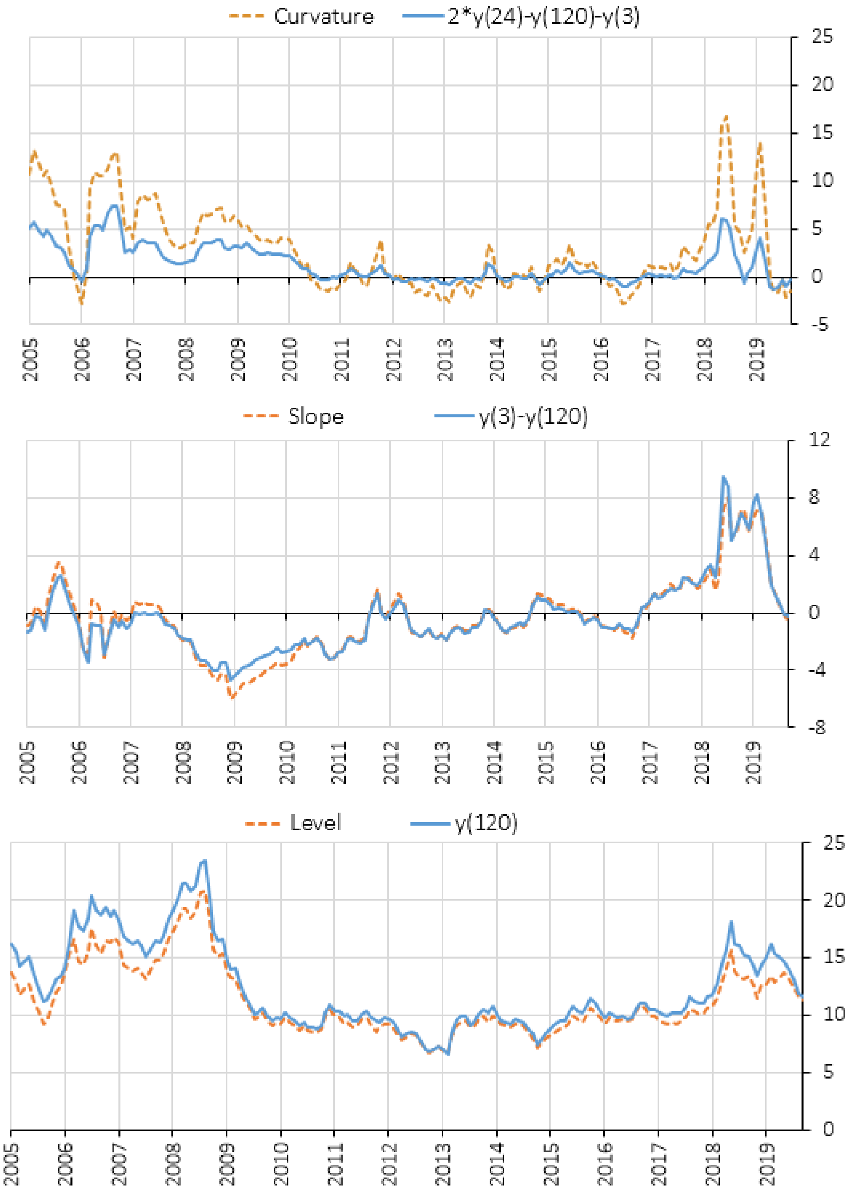
4. Empirical results

In Figure 1, we firstly compare the estimated yield factors with empirical proxies for level, slope, and curvature. Since the level factor is interpreted as a long-term factor, the empirical finance literature approximates the level by the long term interest rate which is a ten-year yield (y120) in our case. Similarly, the

[7]One lag is selected by BIC criteria.

slope is approximated by the difference between a short- and a long-term interest rate (y(3)-y(120)). Finally, the curvature factor can be proxied by the yield difference (2*y(24)-y(3)-y(120)). Figure 1 shows that estimated yield curve factors match closely with their empirical proxies. The level moves most persistently with the least variation while the curvature indicates more variability.

Figure 1: Estimates of yield curve factors



Notes: Solid lines represent the estimates of level, slope and curvatures. Dotted lines correspond to the empirical parts of the factors proxied by y(120), (2*y(24)-y(120)-y(3)), and y(120).

Table 1 reports the oil shock decompositions based on the baseline and modified specifications. While the baseline uses Ready's (2018) identification method, modified is based on the same approach of the Ready (2018), but replaces VIX with the GOPR index. It is evident that the influence of supply shocks almost identical and remains important to describe oil price shifts under both identification schemes. In particular, according to the modified identification method, around 71.55% of the oil price changes are due to supply shocks and 28% to shocks to the demand. The risk shocks play a very limited role in the overall variability of oil prices in contrast to baseline scheme. Interestingly, the demand shocks become much more relevant under the modified scheme indicating that using the VIX conflates information relating to aggregate demand present in volatility as suggested by Clements et al. (2019). Hence, using the GOPR index to identify the risk shocks removes this misclassification and puts a comparatively more significant role for aggregate demand shocks compared to the baseline.

Table 1: Oil shock variance decompositions

Shock	Baseline -Ready (2018)		Modified	
	Stdev.	% of Var.	Stdev.	% of Var.
Risk	0.090	10.95	0.018	0.45
Demand	0.114	17.44	0.144	28.00
Supply	0.230	71.61	0.230	71.55

Note: The table reports the annualised standard deviations for each oil shocks identified based on modified scheme together with the percentage of variance explained by each orthogonal oil shock. Baseline is the identification scheme based on Ready (2018) who utilizes VIX index as a proxy for discount factor shocks in the equity market. Modified scheme replaces the VIX index with GOPR index and utilizes same identification methodology as in Ready (2018).

Figure 2 represents dynamic correlations obtained from the DCC-GARCH(1,1) model. Overall results turn out to validate the argument that co-movements between yield curve component and oil price shocks are not stable over the course of the sample period. The relation between level and risk factor seems to hover around positive front until 2013, whereas negative correlation is observed afterward. On the other hand, the yield curve level is found to have a negative relation for most of the examined durations and it seems to get stronger in recent periods. The level factor describing the long-end of the yield curve is also found to positively correlated with supply shocks and the degree of association becomes more prominent during volatile episodes like Global Financial Crisis and taper-tantrum.

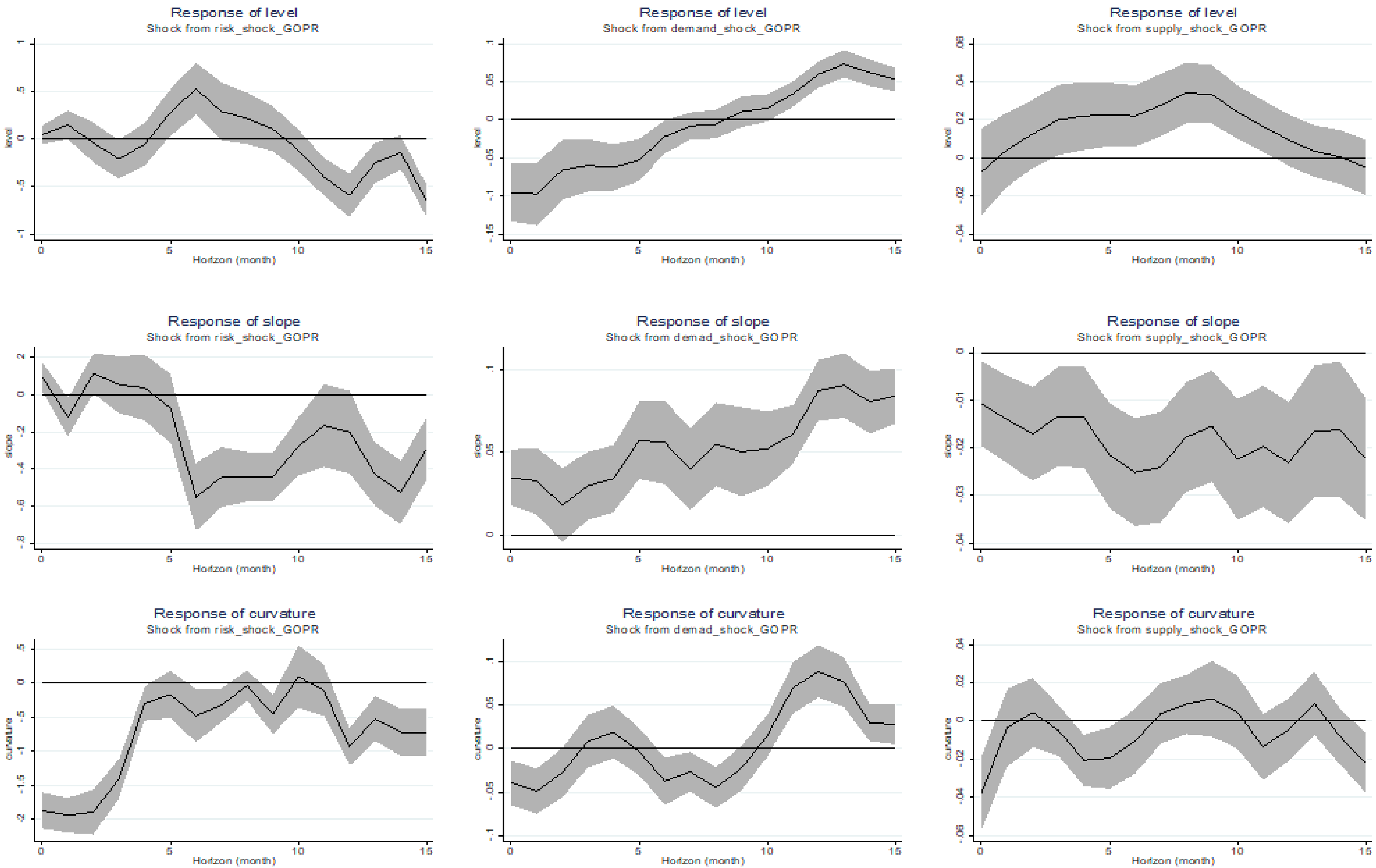
Figure 2: DCC-GARCH (1,1) results - 3 month averages

In contrast to relatively smooth correlations attached to level factor, oil shocks tend to have more volatile correlations with the slope component. Disturbances in risk factor have mildly and negatively correlated with the slope of the yield curve which becomes highly pronounced during 2018 market volatilities in the Turkish economy. Furthermore, a positive and low level of correlation between slope and demand shocks is observed throughout the sample period, except for Global Financial Crisis and 2018 market volatilities. Although the overwhelming majority of observations of dynamic correlations display negative association between slope and supply shocks, it is reversed on a temporary basis over the whole sample period.

Lastly, dynamic correlations regarding curvature factor are reported. It is seen that the relationship with respect to demand and supply shocks are more sizeable compared to the one with risk shock. Overall, negative and positive co-movements with demand shock are documented for demand and supply shocks, respectively. It is a striking finding that curvature is closely aligned with oil supply shocks during recent market volatilities in the Turkish economy.

We now turn to estimate the impacts of the identified oil shocks on yield curve factors. Figure 3 presents the IRFs that are based on the modified scheme. The solid lines show impulse response functions for the oil price shocks and shaded gray areas represent the 68% confidence intervals. The first column of Figure 2 shows that a risk shock leads to a temporary increase in the level factor. The impact of the shock is not persistent and turns to negative after ten months. This result is in line with Cunado et al. (2019) who show that the geopolitical risks have a significant negative impact on oil returns, primarily because of the decline in oil demand by slowly improving global growth environment. Besides, an increase in the GOPR index can be linked to a rise in risk aversion that lowers the demand for commodity-based assets. The flight to safe havens leads the oil prices to decline. While the long-term inflation expectations fall with declining oil prices, the surge in demand for safe-haven assets, such as the US currency, triggers the depreciation of the local currency of a country, such as an oil-importing emerging market, Turkey. Accordingly, depreciation leads to a prevailing impact on the inflation expectations, thus on the level factor. On the other hand, the slope factor initially does not respond to the risk shocks while the succeeding decrease in the slope factor is prominent and does not die out within fifteen months. This response is consistent with the central bank's reaction to support economic activity by decreasing short-term rates because of the negative impact of risk shocks on aggregate demand. Finally, a risk shock is also associated with a decrease in the curvature factor indicating that risk shocks influence the medium-term bonds due to the deflationary pressure resulting from depressed economic conditions.

Figure 3: Responses of the yield curve factors to different oil price shocks



Notes: Solid lines are responses to one-standard deviation shocks in market shocks based on local projections. Shaded gray areas correspond to the 68% confidence intervals.

The effect of unanticipated demand shocks on the estimated yield curves factors is shown in the second column of Figure 3. Although the initial reaction of level factor to demands shocks is negative, the impact turns to be positive nearly after ten months implying that the government initially did not pass the increase in oil prices to the retail level through tax discounts or subsidies. On the other hand, this may result in a stronger output growth through supporting consumption which leads to inflation expectations to increase quickly after ten months. Furthermore, unanticipated demand shocks have a positive impact on the slope factor as a result of the central bank policy response for offsetting the elevated inflation expectations. Hence, investors demand higher long-term rates to keep the future value of their investments which leads to a significant increase in the curvature of the yield curve in the long run.

The third column of Figure 3 shows the impulse response of yield curve factors to oil supply shocks. A supply shock leads to a statistically significant increase in the level factor. This result shows that elevated oil prices due to supply disruptions are interpreted as a signal of surge in inflation expectations since the cost channel prevails. On the other hand, the negative impact of the supply shocks on the slope factor implies that the possible negative effects of oil supply disruption on economic activity can be eliminated by decreasing policy rate. Finally, a supply shock is associated with a contemporaneous decrease in the curvature factor and its impact quickly dies out in a month.

Overall, the different shocks to oil prices are expected to have profound effects on both the price differentials and the production dynamics of the economy. Our findings are in line with the ones reported by Ioannidis and Ka (2018) that use an alternative decomposition developed by Kilian (2009) and investigate the response of the three factors to the oil price shocks for two oil-importing countries (the US and South Korea) and two oil-exporting countries (Canada and Norway). Their results from SVAR estimation suggest the responses vary with respect to the type of the oil price shock, the monetary policy framework of the country, and the degree of its dependence on oil imports. The responses of level, slope, and curvature factors of Turkey's yield curve documented in our study are consistent with that of another oil-dependent country, Korea, reported by Ioannidis and Ka (2018).

5. Conclusion

This paper aims to analyze interdependencies between oil price shocks and yield curve factors of Turkish sovereign bond market. Building on the novel approach of Ready (2018), we try to disentangle different sources of oil price shocks by augmenting geopolitical oil price risk index into the estimation procedure.

It is determined that majority of the price changes in global oil market is driven by supply-side forces, while rest is dominantly represented by demand conditions, whereas risk factor has limited explanatory power. The results of the impulse-response functions generated through local projections method reveal that oil-supply shock is transformed into increase in level component of Turkish sovereign yield curve. This corresponds to the argument that supply shock can be potentially priced by bond investors as additional cost-pushed inflationary impact which would be manifested in a surge in inflation expectations and increase in long-end of the curve. Furthermore, unanticipated demand shocks are determined to cause increase in slope component anticipating a monetary tightening policy response by monetary authority to contain worsening in inflation outlook. In contrast to other studies, we also document that curvature factor is somewhat associated with risk and demand shocks.

Overall, our results provide new insights for policymakers about possible implications of global commodity shocks on local financial conditions. It is also informative for fixed income investors about explaining the behavior of Turkish yield curve in the face of oil shocks in the context of trading and hedging strategies.

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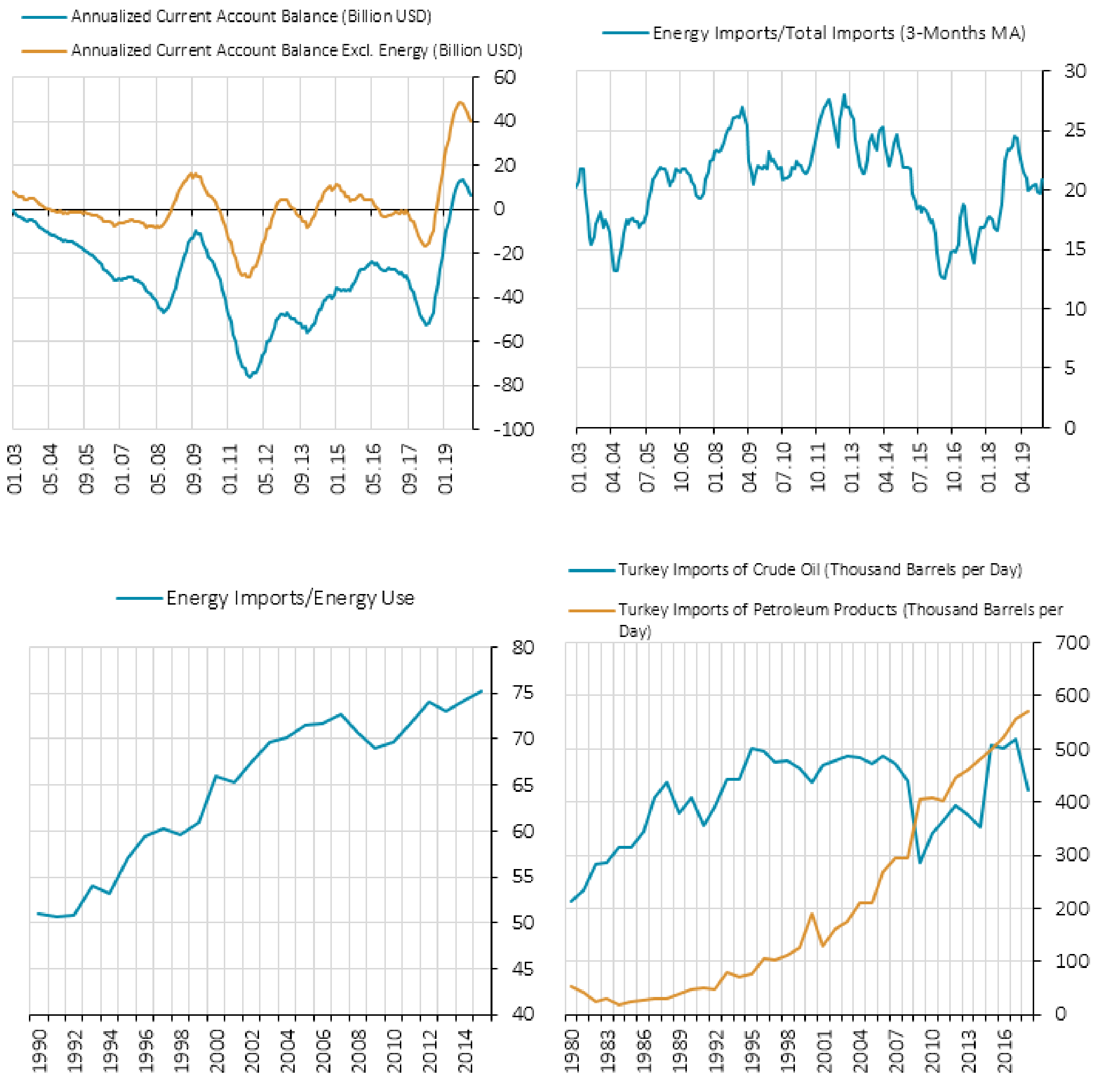
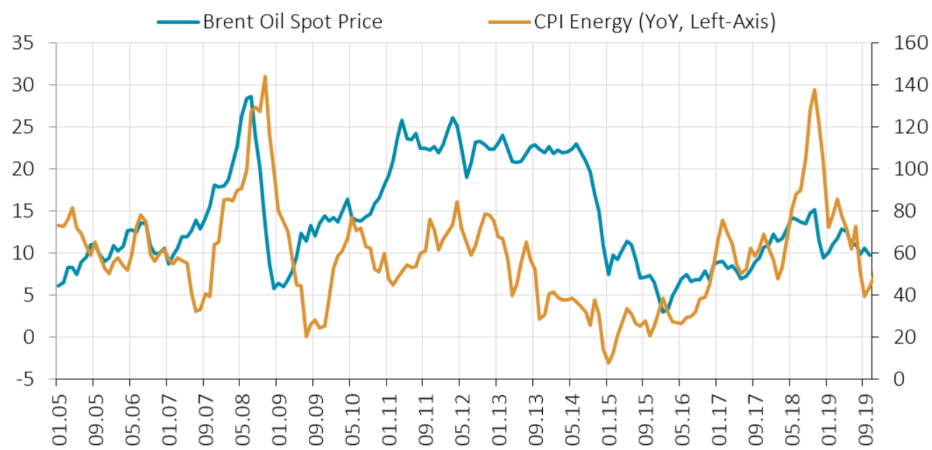
Appendix

Figure A1: Turkey energy imports and current account balance



Notes: Source:CBRT, OPEC and World Bank

Figure A2: Energy Prices and CPI Inflation



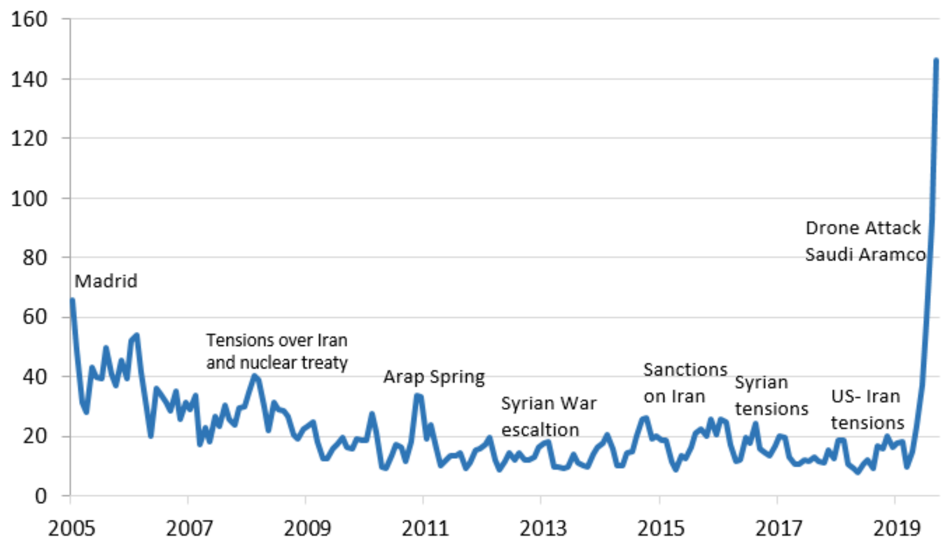
Notes: Source:Turkstat and Bloomberg

Figure A3: Related keywords by group

Number	Group 1: Sanction	Number	Group 4: Economic Uncertainty & Geography
1	oil sanction	1	oil price uncertainty
2	Iraq sanction	2	oil uncertainty
3	Iran sanction	3	Strait of Hormuz oil
		4	Gulf of Aden oil
		5	Suez canal oil
Number	**Group 2: Countries under Political Tensions**	**Number**	**Group 5: U.S. Presidents and Oil Policy**
1	Saudi Arabia oil	1	Carter oil
2	Venezuela oil	2	Reagan oil
3	Libya oil	3	Clinton oil
4	Iraq oil	4	Bush oil
5	Russia oil	5	Obama oil
6	Syria oil	6	Trump oil
Number	**Group 3: Political Events**		
1	Middle Eastern war		
2	Israeli Arab conflict		
3	Gulf war		
4	Terrorism		
5	disruption oil		
6	Aramco oil		
7	OPEC		

Notes: Source:https://business.ucdenver.edu/commodities/applied-research/geopolitical-oil-price-risk-index-goprx.

Figure A4: Geopolitical oil price risk index



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