IJEEP

INTERNATIONAL JOURNAL OF
ENERGY ECONOMICS AND POLICY

ℰJ EconJournals
ISSN: 2146-4553

ℰJ EconJournals

Do Political Factors Influence U.S. Crude Oil Imports?

Jayson Beckman*, Getachew Nigatu

Economic Research Service, 355 E Street SW, Washington, DC 20024, USA. *Email: jayson.beckman@usda.gov
The findings and conclusions in this publication are those of the authors and should not be construed to represent any official USDA or U.S. Government determination or policy.

ABSTRACT

This work uses a gravity model to estimate the determinants of U.S. crude oil imports, introducing two variables tied to the political nature of trade: U.S. arm sales and the level of political freedom in a country. Model results indicate that contiguity is important for U.S. crude oil imports, but trade agreements are not. Being an OPEC member leads to more exports of crude oil to the U.S. These factors combined with the negative relationship with freedom and U.S. crude oil imports, suggests that the U.S. imports a lot of oil from countries that have little cultural and political similarities.

Keywords: Oil, Gravity, Structural Break, U.S., Politics
JEL Classifications: Q4, F1

1. INTRODUCTION

The United States has historically been the world's largest importer of crude oil, importing, on average, 21% of the global value of crude oil imports from 2002 to 2015 (UN Comtrade, 2018). U.S. imports of crude oil have declined from its peak in 2005 largely due to the domestic production growth from the shale oil boom; however, until very recently, the United States was still the largest importer of crude oil.[1] Although crude oil is noted as being the commodity traded the most, its trade is often contentious due to issues such as national security and political factors (Krane and Medlock, 2018; Zhang et al., 2015). The commodity includes, arguably, the most influential cartel in the world, the Organization of Petroleum Exporting Commodities (OPEC), which is responsible for around 42-44% of the world's production of crude oil and 56-60% of oil trade (OPEC, 2017). In addition, crude oil is important enough to influence agricultural commodity prices–through changes in the

exchange rate (Hanson et al., 1993; Harri et al., 2009) or from its relationship with ethanol (Saghaian, 2010).

Changes in political relations and supply issues have transformed the composition of U.S. imports of crude oil over the years. Since the supply disruptions in the Middle East of the late 1970s, the U.S. has turned to favor supply from its Western Hemisphere partners (EIA, 2018b). In particular, imports from Canada and Mexico have increased in importance, while Saudi Arabia, who was the dominant supplier until the late 1980s, has experienced a decrease in export share. The other main suppliers to the United States are either relatively close (for example almost all South American countries export to the U.S.) or they are the recipient of a free trade agreement with the U.S. (e.g., Australia). Saudi Arabia's national security concerns dictate that it maintains a very high profile as a supplier to the U.S., even if it means fewer profits (EIA, 2006).

Despite the increasing reliance on its closest neighbors- Canada and Mexico, the U.S. still imports a third of its oil from OPEC countries (EIA, 2018a). These countries tend to be categorized as developing countries that are not politically stable. The literature shows politics can influence crude oil trade flows. Du et al. (2017) find evidence

---

1 China surpassed the U.S. in crude oil imports as the world's largest crude oil importer in 2017 (EIA, 2018a); however, this paper focuses on the U.S. for reasons explained later in the introduction. Research has examined the topic of China's crude oil importing patterns (Shao et al., 2017).

of short-run changes from political shocks on exports to China; Fuchs and Klann (2013) conclude that a visit from the Dalai Lama to a country reduces their exports to China the next year; and Heilmann (2016) estimates a reduction in trade from political events that call for boycotts. Summary (1989) makes the argument that bilateral cooperation and conflict is positively associated with levels of bilateral trade. U.S. oil trade and politics has been investigated by Kashcheeva and Tsui (2015) who use micro-level data to examine what kinds of firms are more responsive to change in political distance between the U.S. and its trading partners, measured by divergence in their UN General Assembly voting patterns. Mityakov et al. (2013) use a gravity model to examine U.S. imports of crude oil, also using the political distance factor as was done in Kashcheeva and Tsui (2015). Using data from 1962 to 2000, their results indicate that a divergence in UN voting patterns has a small, significant impact on U.S. oil imports.

Our paper is similar to these papers–in that we are interested in determining if certain political factors and energy policy influence U.S. oil imports. In his 2007 State of the Union address, President George W. Bush stated that U.S. reliance on foreign oil has rendered the nation's interests "vulnerable to hostile regimes, and to terrorists who could cause huge disruptions of oil shipments, and raise the price of oil, and do great harm to our economy." To test if political factors influence U.S. oil imports we construct two variables in a gravity model that goes beyond voting patterns: U.S. arm sales to countries, and the amount of political freedom in a country. To examine energy policy factors affecting U.S. oil imports, we test whether OPEC remains an important sources of U.S imports or if the U.S turns to those whom they have free trade agreements with. We are also interested in examining what standard gravity model explanatory variables (common language, distance, and trade openness) impact U.S. oil imports. Crucially, one point we make in this paper is that there is likely a structural break in U.S. oil imports, due to the fall in imports since 2006. We test for the break (and find one), thus we decompose our data into two periods: rising U.S. oil imports (1993-2006) and falling U.S. oil imports (2007-2016). This phenomenon would not have been observed in papers such as Mityakov et al. (2013) and Kashcheeva and Tsui (2015) because their data stops at the year 2000 and 2008.

2. BACKGROUND

Given the importance of crude oil in the economy, the literature has focused on explaining different aspects of the commodity. Among the aspects, examining fluctuations in crude prices and explaining trade patterns have received, perhaps, the most attention (e.g., Prest, 2018; AlKathiri et al., 2017; Zhang et al., 2015). As our paper focuses on trade patterns, we look deeper at the literature on this topic. In addition, background information on U.S. crude oil imports is provided in this section.

2.1. Literature Review

The topic of explaining crude oil flows has been investigated in the literature using a variety of methods. AlKathiri et al. (2017) use a simulation model to examine the ability of large crude oil traders to influence inter-regional price differentials. Research has also examined global oil trade using network theory. An et al. (2014)

specify a trading-based network model of international crude oil to study the relationship between countries with common trade partners. Ji et al. (2014) construct a global oil trade core network to analyze oil trade using complex network theory. Further work has examined the relationship between oil prices and macro factors. Amin et al. (2021) examine the nexus between oil price and exchange rate for Bangladesh's economy. Alkhateeb et al. (2021) study the role of oil in fiscal policy cyclicality in Saudi Arabia. Endri et al. (2021) study the effect of oil prices on the stock market in Indonesia.

Zhang et al. (2015) use spatial econometric modeling of origin–destination flows to identify and analyze the driving factors for the formation of current oil trade patterns. They find that most oil exporters have a focus on exports to North America. They note that technological progress and energy efficiency have significantly influenced oil trade, beyond the common supply and demand factors. Other work that has used a gravity-type model on trade in energy commodities include Zhang et al. (2018), who investigate the determinants of liquefied natural gas (LNG) trade. Note that their work includes a political risk index variable, with results of the gravity model indicating that importing countries are more willing to import LNG from regions with stable political environments.

2.2. U.S. Crude Oil Imports

Much attention has been made recently about the tremendous increase in U.S. crude oil production, but Figure 1 indicates that the U.S. produced more crude oil than it imported as recently as 1993. U.S. production of crude oil was 2.71 billion barrels in 1991, and decreased to 1.83 billion barrels by 2008 (a decrease in production of 32.4%). This decrease in production was largely a function of low global prices, as the turnaround in U.S. crude oil production after 2008 was fueled by high global prices making fracking and other technologies profitable. As U.S. gross domestic product (GDP) continued to grow from 1991 to 2008, so did its demand for crude oil. This increase in U.S. crude oil demand was filled largely by imports as shown in Figure 1. Indeed, the increase in U.S. crude oil imports and GDP from 1991 to 2008 were 70% and 66%, respectively. U.S. crude oil imports, however, plateaued in the mid-2000s, and declined beginning in 2006. This decline in imports coincided with an increase in U.S. crude oil production.

Despite the reduction in U.S. crude oil imports after 2006, the United States remained the largest importer of crude oil, globally, when China became the largest importer in 2017 (EIA, 2018a). Changes in politics, energy policy and trade agreements have changed the sources of U.S. crude oil imports over time. Figure 2 indicates that Saudi Arabia provided the largest share of crude oil to the U.S. until 1993, when the Canada and Mexico combination became the largest source, providing more than 45% of crude oil imports. However, for individual countries, Saudi Arabia remained the largest source until 2006, since then, Canada has become the largest source of crude oil to the U.S. The share of imports from Saudi Arabia has remained around 15%, but note the large increase in imports from Canada and Mexico. There are two factors for this: the implantation of the North American Free Trade Agreement (NAFTA) in 1994, and the increase in Canada's shale oil production. Crude oil from those two countries have replaced imports from Nigeria and kept the share from other Middle East and Russia small.

Globally, sources of crude oil imports present a different picture than that for the U.S. Figure 3 indicates that the current largest source is the other Middle East composite, which is largely from Iran, Iraq, Kuwait and the United Arab Emirates. The decrease in other Middle East share from 1990 to 1994 was a result of the Gulf War. Saudi Arabia has also experienced a decline in its share of global crude oil imports, but the share has remained above 15% (like that for the U.S.). The largest gain in share has, however, been

Figure 1: U.S. crude oil imports and production, and U.S. GDP (1991-2016)
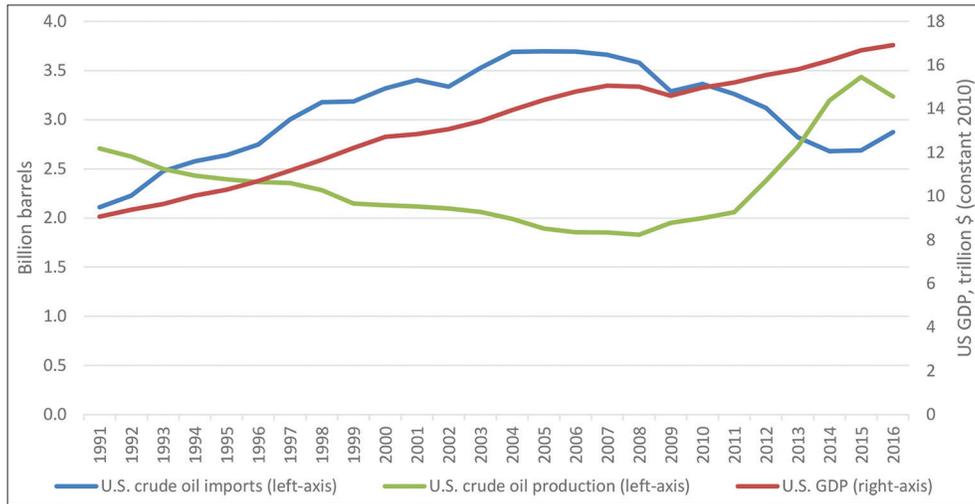
Source: EIA (2018b) and World Bank (2018)

Figure 2: Source of U.S. crude oil imports (1990-2017)
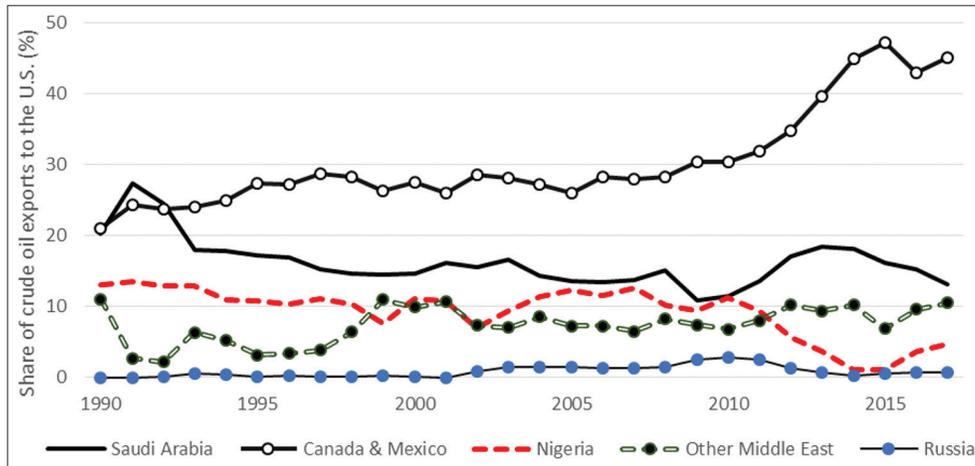
Source: UN Comtrade (2018). Other Middle East included: Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Syria, and the United Arab Emirates

Figure 3: Source of global crude oil imports (1990-2017)
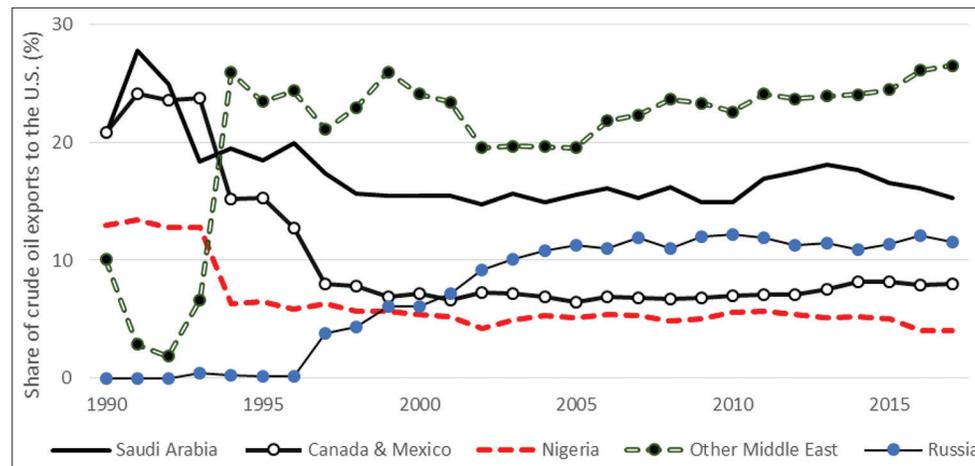
Source: UN Comtrade (2018). Other Middle East included: Bahrain, Iran, Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Syria, and the United Arab Emirates

for Russia. It went from exporting very little crude oil in 1996 to becoming the second largest exporter after Saudi Arabia. Note, that the U.S. imports very little crude oil from Russia.

3. GRAVITY MODEL

The work by Tinbergen (1962) first linked the pattern of bilateral trade to national income, population, and distance. Much of the literature using the gravity model has used aggregated data to examine bilateral trade flows between a large collection of countries. There has been less research examining specific commodities; however, the gravity specification can lend insight into the flow of trade of specific commodities. This paper seeks to contribute to the literature examining specific commodities by using the gravity specification to evaluate the determinants of U.S. crude oil trade imports.

In one of the first studies to specify a commodity specific model, Koo et al. (1994) examine the trade flows of meat using a commodity specific gravity model. Dascal et al. (2002) use the commodity specific gravity model in order to analyze the main factors affecting the trade flows of wine in the European Union. Prentice et al. (1998) specify an empirical gravity model for Canadian pork exports to the United States to identify the particular regions in the U.S. where pork exports from each province in Canada could be expanded.

3.1. Methods

Here we use the gravity model developed by Anderson and van Wincoop (2003). The basic conceptual idea is presented in Equation (1):

$$Oil_{us,t} = f(GDP_{us,t}, GDP_{it}, Dis_{us-i,t}, \pi_{us-i,t}) \quad (1)$$

At each point in time t, the volume of U.S. crude oil imports from its trading partners i $Oil_{us,t}$,[2] depends on U.S. GDP ($GDP_{us,t}$), the GDP of its trading partners (GDP_{it}), the average physical distance between the U.S. and the trading partner ($Dis_{us-i,t}$), and a number of trade limiting or/and enabling factors, $\pi_{us-i,t}$, such as sharing a border (contiguity), having a bilateral free trade agreement (FTA), having a similar official language (common language), stable exchange rate regimes (exchange rate), the level of trade openness (trade openness), membership in similar international trade institutions such as World Trade Organization (WTO) and/or Organization of Petroleum Exporting Countries (OPEC), and the political economy factors (freedom index) and U.S. arm sales (U.S. arm sales).

The estimation is performed using a log-linearize specification, shown in Equation (2):

$$Ln\ Oil_{us,t} = \beta_o + \beta_1 \ln GDP_{us,t} + \beta_2 \ln GDP_{it} + \beta_3 \ln Dis_{us-i,t} + \beta_j \sum_j \pi_{us-i,t} + \varepsilon_{us-i,t} \quad (2)$$

where the coefficient for β_1, β_2, β_3 and some non-dummy variables from β_j (such as trade openness, exchange rates) are interpreted as the elasticity of U.S. crude oil imports with respect to changes in the independent variables.

When it comes to estimation techniques[3], there is no one general best performing estimation, and the selection of the estimation techniques depends on a number of factors (Kareem, 2013). Piermartini and Yotov (2016) noted that gravity estimates in the existing literature suffer biases and inconsistency despite the progress in gravity model applications. They also reviewed some drawbacks and possible solutions. For instance, the presence of zero trade flows in a number of observations would make the Ordinary Least Square (OLS) estimation approach impossible when the volume of trade is transformed into a logarithmic form. This can be solved by use of the Poisson Pseudo Maximum Likelihood (PPML) estimator that was advocated by Santos Silva and Tenreyro (2006). PPML can also provide a consistent estimate in the presence of heteroscedasticity. In addition, Feasible Generalized Least Square (GLS) can also be used with the problem associated with log normal formulation and the presence of zero valued trade flows (Kareem, 2013). As shown next in the data section, we do not anticipate a problem as a result of zero or missing data in most of our data series. Nevertheless, we present the results using GLS, OLS, and PPML estimation techniques for robustness.

3.2. Data

The literature notes that trade flows in crude oil are largely a result of advantages in transportation costs and preferences for different qualities (Grant et al., 2006). This makes the gravity model a good candidate to explain trade flows. The gravity model can be used to trace and understand the flow of goods with the understanding that the volume of bilateral trade tends to vary directly with market size and inversely with distance (Prentice et al., 1998).

Table 1 presents descriptive statistics for the variables used in our gravity model, with units and source of data reported in the 2nd and 3rd columns, respectively. The mean GDP indicates that the U.S. has, on average, a GDP 34 times larger than that of the countries it imports crude oil from. The distance variable is the distance between capital cities in a country, the mean value of 8,784 kilometers is the distance from Washington DC, the U.S. capital, to Abuja, the capital of Nigeria. This paper utilizes data from Freedom House to construct the political variable. This data base (Freedom House, 2018) measures freedom as the opportunity to act spontaneously in a variety of fields outside the control of the government and other centers of political domination, according to two board categories: political rights and civil liberties. The variable ranges from 1 to 7, with a value closer to 7 indicating less freedom in a country. We include free trade agreements that

---

2   We drop those countries that have never reported global trade more than $100,000 to UN Comtrade for HS code 270900. They are: Afghanistan, Andorra, Armenia, Antigua and Barbuda, Bhutan, Bosnia and Herzegovina, Burkina Faso, Burundi, Cambodia, Central African Republic, Comoros, Cabo Verde, Djibouti, Dominica, Eritrea, Ethiopia, Fiji, Guinea Bissau, Grenada, Haiti, Honduras, Iceland, Kiribati, Laos, Luxembourg, Malawi, Mauritius, Micronesia, Maldives, Montenegro, Mozambique, Nepal, Nicaragua, Niger, North Korea, Palau, Rwanda, Saint Kitts and Nevis, Saint Vincent, Seychelles, Sierra Leone, Somalia, South Sudan, Sri Lanka, Tajikistan, Uzbekistan, Zimbabwe.

3   One of the determining factor is the assumption implied for the error terms, $\varepsilon_{us-i,t}$. Shepherd (2013) provides detailed explanation for selecting each of the techniques. For instance unlike OLS, PPML assumes ln ($\varepsilon_{us-i,t}$).

**Table 1: Descriptive statistics for variables in the gravity model**

Variables	Units	Source	Number of observations	Mean	Standard deviation	Minimum	Maximum
U.S. GDP	Constant billion U.S.$	World Bank	1,080	13,620	2,129	9,637	16,920
Exporters' GDP	Constant billion U.S.$	World Bank	1,080	402	866	0	9,505
Distance	Kilometer	CEPII	1,080	8,784	3,725	734	16,371
Freedom index	Index ranges from 1 to 7	Freedom House	1,080	4.32	1.92	1	7
Free trade agreement	Member = 1, otherwise = 0	USTR	1,080	0.09	0.29	0	1
Common language	Common language=1, otherwise = 0	CEPII	1,080	0.16	0.36	0	1
OPEC	Member = 1, otherwise = 0	OPEC	1,080	0.24	0.42	0	1
WTO	Member = 1, otherwise = 0	WTO	1,080	0.76	0.43	0	1
Contiguity	Contiguity = 1, otherwise = 0	CEPII	1,080	0.04	0.21	0	1
U.S. arm sales	Millions U.S.$	SIPRI	522	171	318	0	2,212
Exchange rate	Offcial exchange rate in local currency/U.S.$	World Bank	1,070	751	2,775	2.70E-06	21,935
Trade openness	Trade (% of GDP)	World Bank	1,064	79.3	46.8	0.0	531.7
U.S. crude oil imports	Million barrels	EIA	871	87	165	0	1,200

the U.S. has in place as a dummy variable in the model. Other dummy variables revolve around common measures of trade: common language, contiguity (which will only be Canada and Mexico), if a country is part of the World Trade Organization (WTO), and the exchange rate of the exporting country.

Other variables we include in our model are if a country is a member of OPEC and a measure of their trade openness. Almost one quarter of the trading partners are member of OPEC between 1993 and 2016. Trade openness is based on data from World Bank (2018) and calculates the share of a countries' trade (both exports and imports) as a share of their GDP. The average trade openness for U.S. trading partners was around 47%, almost twice more open than the United States. The final variable we include in our gravity model is U.S. arm sales. The data is provided by the Stockholm International Peace Research Institute (SIPRI, 2018); and it measures the dollar value of U.S. arms exports to countries. For both SIPRI and the Freedom House variables, the working hypothesis is that the U.S. would tend to trade with countries that have a higher freedom index and who the U.S. exports arms to (this could serve as a proxy for countries that the U.S. might have closer political relations with). Note that the number of observations in arms sales is 522, while there are 1080 observations on U.S. oil imports. Thus, the U.S. has arms sales to a little less than half of the observation that it imports oil from.

To better understand the political variables used in this work, Figure 4 plots U.S. arms sales and the Freedom Index. Note that there are many countries that have either no arm sales (former USSR, some African, Asian, and Central American countries) or they purchase arms from the U.S. in small amounts (e.g. Libya). Moving past the $200 million arms sales amount, the U.S. tends to sale arms to countries that either have a lot of freedom (an index between 1 and 2) or that have little freedom (an index greater than 4). Some examples of the latter include: Saudi Arabia ($792 million), Egypt ($577 million), and the United Arab Emirates ($413 million) average arm sales during 1993-2016. Their corresponding Freedom Indexes are: 6.875, 5.667, and 5.708, respectively.

Figure 4: Average U.S. arms sales and average Freedom Index (1993-2016)
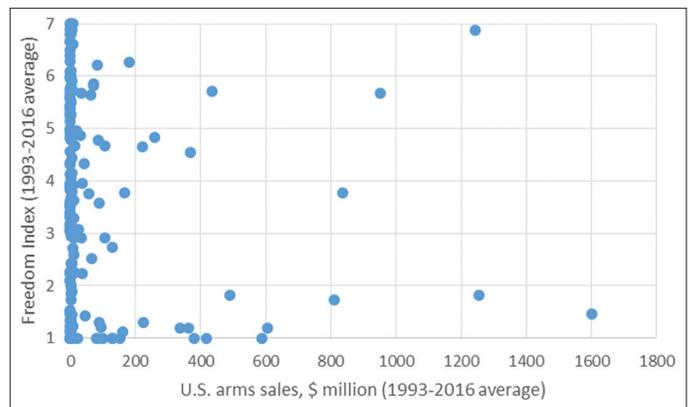
4. RESULTS

We begin our discussion of results with the test of a structural break, since Figure 1 indicates that U.S. crude oil imports seemed to face two regimes: increasing imports until the mid-2000s, then decreasing imports since then. We will present the results for the specified gravity model based the resulting timeline indicated from the structural change test.

4.1. Structural Break?

We test for a structural break in U.S. crude oil import data, assuming that the break point is not known. This Wald test is done by combining the test statistics computed for each possible break date in the sample. The null hypothesis of the test is that there is no structural break, the results noted in Table 2 indicate that we can reject the null hypothesis at the 1% confidence level and that the structural break occurred in 2006. With this information in hand, we estimate the gravity model over three sample periods: 1993-2006, 2007-2016, and the entire sample: 1993-2016. In the next step we estimate a basic form of the gravity model, which only includes the GDP variables, distance, and contiguity. Each successive table presents the results when we add other variables to the model. Our results are compared with those of Mityakov et al. (2013), the work most similar to ours.

4.2. Basic Gravity Model Results

Table 3 presents the econometric results for the basic gravity specification.[4] These results indicate that U.S. crude oil imports are inversely related to U.S. GDP; although the results are not statistically significant for the PPML estimation. The literature notes that this coefficient is most often positive in a gravity model; however, recall the decrease in U.S. crude oil imports over the time-frame (and the increase in U.S. GDP). The coefficient on exporters' GDP is positive and significant across all time frames, indicating that the U.S. tends to import crude oil from countries who have an increasing GDP. Distance is inversely related to U.S. crude oil imports, as suggested by the literature. Contiguity is positive, as the U.S. imports more than 45 per cent of its crude oil from Canada and Mexico. The sign on the coefficients and statistical significance are the same across all three econometric methods for contiguity. This basic model gives an adjusted R-squared of around 0.27 for the GLS and OLS estimation, but the PPML specification provides a better fit for the data (i.e., a larger adjusted R-squared). Note that none of these variables are included in Mityakov et al. (2013). Pursuant to our structural break, none of the variables in Table 3 have a change in sign; although the magnitude changes across time frames and U.S. GDP becomes statistically significant in one time-frame, but not the other.

4.3. Gravity Model Results with Major Determinants of Trade

Table 4 presents the model results when major determinants of trade are added to the basic model. U.S. GDP, exporters' GDP, distance, and contiguity all have the same sign as the baseline

---

4   We start off with 1080 total observations for most variables, but U.S. crude oil imports only have 871 variables. Additionally, there are a couple of other variables with missing years, thus our model across the full time-frame has 859 complete observations.

Table 2: Structural break test of U.S. crude oil imports

Number of obs=	24
Full sample:	1993-2016
Trimmed sample:	1997-2013
Estimated break date:	2006
Ho: No structural break	

Test	Statistic	P-value
Swald	249.0137	0.0000

model and all are statically significant (and this time, U.S. GDP is statistically significant for two of the three PPML estimates). There are stronger coefficients (in terms of magnitude) for these variables compared to the basic model. This model adds the FTA member variable, which has a negative value even though the U.S. has an FTA with both Canada and Mexico, the largest supplier of U.S. crude oil imports. The negative result occurs because most of the relationship among Canada, Mexico and the U.S. is being captured in the contiguity variable. And, the U.S. has an FTA with five other countries (Australia, Colombia, Guatemala, Oman, and Peru) who it imported small amounts of crude oil. Note that the Mityakov et al. (2013) work had a positive coefficient for FTAs; however, their database stretched from 1962 to 2000, a period when the U.S. only had trade agreements with Canada, Israel (who it did not import oil from), and Mexico. All other trade agreements where added after the year 2000. And their work did not include the contiguity variable. The coefficient on common language is negative across all specifications, but only statistically significant for the 2007-2016 time-frame (and the entire sample for the GLS specification). The literature indicates that language barriers are significantly negatively correlated with trade, while common language directly increases trade flows. However, in our case, the U.S. imports crude oil from many countries that do not have English as their official language (Mexico, Saudi Arabia and Other Middle East).

The coefficient on the OPEC member dummy variable is positive, indicating that the U.S. is more likely to import crude oil from countries that belongs to the organization. However, note that the coefficient for the 2007-2016 time period is not statistically significant for the GLS and OLS estimates. This is because of two things. First, U.S. crude oil imports from OPEC declined from 2 billion barrels in 2006 to 1.26 billion barrels in 2016. The second concerns the coefficient on WTO membership and the WTO OPEC interaction term. The WTO membership coefficient is positive for the 1993-2006 time frame (and the entire sample), but it is negative for the 2007-2016 time-frame.[5] This result occurs because Saudi Arabia became a WTO member in 2006, i.e., all the influence Saudi Arabia has

---

5   The coefficient on WTO membership is positive and statistically significant for many of the specifications in Mityakov et al. (2013), but as mentioned before, their time-frame is until the year 2000.

Table 3: Gravity results with basic determinants of trade (baseline)

Variables	GLS			OLS			PPML		
	1993-2006	2007-2016	1993-2016	1993-2006	2007-2016	1993-2016	1993-2006	2007-2016	1993-2016
US GDP	−0.539**	−6.922***	−1.549***	−0.643	−6.256***	−1.486***	0.18	−1.257	−0.314
Constant$	(0.272)	(0.961)	(0.260)	(0.600)	(1.943)	(0.390)	(0.456)	(1.351)	(0.293)
Exporters' GDP	0.348***	0.320***	0.266***	0.354***	0.362***	0.354***	0.276***	0.295***	0.278***
Constant$	(0.023)	(0.036)	(0.027)	(0.047)	(0.061)	(0.038)	(0.030)	(0.034)	(0.023)
Distance	−1.143***	−0.731***	−0.861***	−1.033***	−0.840***	−0.931***	−0.390***	−0.622***	−0.482***
	(0.071)	(0.095)	(0.074)	(0.137)	(0.181)	(0.112)	(0.113)	(0.099)	(0.080)
Contiguity	0.581***	2.128***	1.716***	0.820***	1.674***	1.208***	0.695***	0.754***	0.741***
	(0.218)	(0.166)	(0.178)	(0.311)	(0.352)	(0.233)	(0.265)	(0.208)	(0.177)
Constant	27.445***	217.855***	57.227***	29.355	197.627***	53.815***	2.144	46.957	17.675**
	(8.184)	(29.168)	(7.844)	(18.012)	(58.894)	(11.771)	(13.896)	(41.042)	(8.936)
Observations	484	375	859	484	375	859	496	375	871
Adjusted R^2	0.278	0.280	0.270	0.273	0.274	0.272	0.388	0.667	0.490

The dependent variable is US crude oil import; all non-dummy variables are in log format. Standard errors in parentheses. *P < 0.10, **P < 0.05, ***P < 0.01

Table 4: Gravity model with major determinants of trade

Variables	GLS			GLS			PPML		
	1993-2006	2007-2016	1993-2016	1993-2006	2007-2016	1993-2016	1993-2006	2007-2016	1993-2016
US GDP	−1.220***	−7.356***	−2.419***	−1.684**	−8.132***	−2.235***	−0.06	−2.133*	−0.753***
Constant$	(0.388)	(0.795)	(0.299)	(0.653)	(1.591)	(0.398)	(0.391)	(1.238)	(0.267)
Exporters' GDP	0.357***	0.293***	0.329***	0.384***	0.204***	0.357***	0.313***	0.421***	0.347***
Constant$	(0.032)	(0.040)	(0.033)	(0.050)	(0.065)	(0.044)	(0.042)	(0.066)	(0.036)
Distance	−1.275***	−0.937***	−1.054***	−1.177***	−0.959***	−1.150***	−0.379***	−0.766***	−0.500***
	(0.088)	(0.098)	(0.079)	(0.122)	(0.159)	(0.103)	(0.090)	(0.108)	(0.072)
Contiguity	1.317***	3.098***	2.231***	1.325***	3.024***	1.793***	1.809***	1.534***	1.666***
	(0.383)	(0.231)	(0.238)	(0.476)	(0.396)	(0.298)	(0.267)	(0.342)	(0.238)
FTA	−0.754***	−0.559***	−0.652***	−0.52	−0.165	−0.390**	−0.363	0.296	−0.114
	(0.256)	(0.172)	(0.160)	(0.391)	(0.230)	(0.197)	(0.234)	(0.281)	(0.203)
Common language	−0.074	−0.274**	−0.311***	0.085	−0.445**	−0.201	−0.198	−0.186	−0.151
	(0.102)	(0.137)	(0.102)	(0.155)	(0.199)	(0.132)	(0.147)	(0.136)	(0.103)
OPEC	1.889***	0.016	1.681***	1.976***	0.461	1.578***	2.415***	0.811***	2.340***
	(0.268)	(0.306)	(0.229)	(0.350)	(0.366)	(0.286)	(0.184)	(0.276)	(0.194)
WTO	0.305**	−1.131***	0.573***	0.462**	−0.820***	0.226	0.571***	−0.465***	0.504***
	(0.126)	(0.174)	(0.131)	(0.207)	(0.262)	(0.162)	(0.150)	(0.175)	(0.141)
WTO*OPEC	−0.097	2.803***	0.537**	−0.547	2.179***	0.324	−0.799***	1.634***	−0.475**
	(0.300)	(0.322)	(0.249)	(0.432)	(0.423)	(0.328)	(0.214)	(0.289)	(0.204)
Trade openness	0.481***	−0.337***	0.300***	0.582***	−0.740***	0.305**	0.134	−0.026	0.024
	(0.095)	(0.110)	(0.086)	(0.093)	(0.218)	(0.143)	(0.104)	(0.184)	(0.084)
Exchange rate	−0.043**	0.110***	0.017	0.001	0.116***	0.043**	−0.048**	0.067***	−0.013
	(0.017)	(0.019)	(0.015)	(0.026)	(0.028)	(0.020)	(0.021)	(0.025)	(0.017)
Constant	46.512***	235.301***	81.732***	58.131***	262.659***	76.348***	6.578	70.609*	27.896***
	(11.453)	(24.111)	(8.802)	(19.160)	(48.015)	(11.708)	(11.775)	(37.517)	(7.995)
Observations	475	370	845	475	370	845	485	370	855
Adjusted R2	0.416	0.543	0.428	0.411	0.545	0.429	0.676	0.805	0.688

The dependent variable is U.S. crude oil imports; all non-dummy variables are in log format. Standard errors in parentheses. *P<0.10, **P<0.05, ***P<0.01

on U.S. oil imports is now being filtered into the interaction term. Along with the change of the sign on OPEC and WTO, trade openness also has a sign change when comparing our earlier and later time-frames. Finally, compared to the basic model, the adjusted R-squared is improved in this model with trade variables.

4.4. Gravity Model Results with Political Factors
A third model includes all the previous variables, but now includes our two political factors: Freedom Index and U.S. arms sales. Table 5 presents those results. First, focusing on the importance of those two variables in the model, note that the variable for U.S. arms sales is statistically significant in the GLS model, indicating that the U.S. is more likely to import crude oil from countries that it sales arms to. However, this variable is not statistically significant for all time-frames in the OLS and PPML specifications. The Freedom Index variable is statistically significant (at the 1%) level across all methodologies and time-frames (except for the 1993-2006 period in the OLS estimation), and the sign is positive. This indicates that a country with a lower level of Freedom Index is more likely to export crude oil to the United States (recall that the Freedom Index is inversed in terms of freedom). The magnitude for both of these political variables is stronger in the 2007-2016 time-frame compared to the earlier time-frame.

The table also indicates that the same thing occurs for the coefficient on OPEC, WTO, and their interaction term. The coefficients on OPEC and WTO are positive in the 1993-2006 time-frame, but not so in the 2007-2016 time-frame. Again, this occurs because of the interaction term: being a member of

both OPEC and the WTO increases the likelihood that the U.S. imports oil from that country. Trade openness is statistically significant and negative across 7 of the 9 time-frame/econometric combinations–indicating that the U.S. imports crude oil from countries that are less open. Contiguity, common language, exchange rate, and the FTA member dummy variable are not always statistically significant, indicating that much of the variance is being accounted for in the political variables. But, overall, this model with political factors has the highest adjusted R-squared compared to the earlier models.

4.5. Robustness Results
The final table presents the results for different model specifications when dummy variables are one, as a robustness check of our results. The results are presented for the GLS model, results using the other methods are available upon request. The first three columns of results in Table 6 are for those who are members of the WTO. The coefficients on U.S. and exporters' GDP are the same as in the previous models. Indeed, most of the variables have the same sign and statistical significance as those in the previous model; however, the U.S. arm sales variable is now no longer statistically significant.

The second three column in Table 6 presents the results for FTA partners. This time, the coefficient on U.S. GDP is positive (across the entire time-frame), as can be expected from the increase in U.S. crude oil imports from Canada and Mexico. Some additional variables also have a change in sign when examining the results for the entire time-frame. Distance is now positively related to crude oil imports, mainly because U.S. imports of crude oil are

Table 5: Gravity model with political factors

Variables	GLS			OLS			PPML		
	1993-2006	2007-2016	1993-2016	1993-2006	2007-2016	1993-2016	1993-2006	2007-2016	1993-2016
US GDP	−0.137	−6.319***	−1.769***	−1.37	−6.362***	−1.995***	0.568	−0.991	−0.26
$constant	(0.555)	(1.177)	(0.360)	(0.996)	(2.138)	(0.514)	(0.432)	(1.166)	(0.301)
Exporters' GDP	0.312***	0.590***	0.304***	0.359***	0.409***	0.374***	0.391***	0.700***	0.470***
Constant	(0.050)	(0.098)	(0.053)	(0.110)	(0.141)	(0.087)	(0.088)	(0.102)	(0.063)
Distance	−1.697***	−1.961***	−1.680***	−1.459***	−1.897***	−1.596***	−0.666***	−2.010***	−1.021***
	(0.112)	(0.141)	(0.093)	(0.154)	(0.198)	(0.129)	(0.123)	(0.255)	(0.105)
Contiguity	0.543	0.332	0.597**	0.579	0.879	0.814**	1.350***	0.405	0.991***
	(0.469)	(0.335)	(0.288)	(0.621)	(0.547)	(0.406)	(0.285)	(0.270)	(0.247)
FTA	−0.730**	0.453**	0.025	−0.03	0.244	−0.002	0.001	0.177	0.203
	(0.321)	(0.199)	(0.184)	(0.478)	(0.298)	(0.242)	(0.149)	(0.172)	(0.150)
Common language	0.249	−1.131***	−0.392***	0.22	−0.635	−0.121	−0.373	−0.851**	−0.408**
	(0.156)	(0.224)	(0.152)	(0.241)	(0.498)	(0.255)	(0.230)	(0.397)	(0.174)
OPEC	2.525***	0.29	2.215***	2.328***	0.424	1.884***	2.193***	0.652	2.219***
	(0.249)	(0.696)	(0.252)	(0.531)	(0.759)	(0.458)	(0.247)	(0.563)	(0.216)
WTO	0.481**	0.061	0.626***	0.31	0.044	0.415	0.364**	0.737*	0.602***
	(0.191)	(0.417)	(0.179)	(0.312)	(0.544)	(0.254)	(0.179)	(0.403)	(0.170)
WTO*OPEC	−1.007***	1.759**	−0.469*	−0.852	1.643*	−0.216	−0.809***	1.235**	−0.724***
	(0.300)	(0.741)	(0.267)	(0.595)	(0.840)	(0.491)	(0.241)	(0.598)	(0.193)
Trade openness	−0.299**	−0.580***	−0.284**	−0.115	−0.863***	−0.381**	−0.271	−0.547**	−0.489***
	(0.124)	(0.171)	(0.121)	(0.199)	(0.318)	(0.178)	(0.174)	(0.244)	(0.146)
Exchange rate	−0.076***	0.024	−0.021	−0.042	0.047	−0.002	−0.074***	0.031	−0.042**
	(0.020)	(0.028)	(0.016)	(0.034)	(0.036)	(0.025)	(0.027)	(0.023)	(0.018)
US arm sales	0.071**	0.084*	0.069**	−0.003	−0.011	0.01	0.019	−0.101**	0.033
	(0.030)	(0.047)	(0.030)	(0.059)	(0.085)	(0.042)	(0.028)	(0.050)	(0.023)
Freedom index	0.165***	0.385***	0.159***	0.105	0.276**	0.190***	0.186***	0.577***	0.314***
	(0.039)	(0.069)	(0.041)	(0.069)	(0.116)	(0.061)	(0.055)	(0.063)	(0.043)
Constant	21.102	204.027***	69.982***	54.412*	211.089***	74.698***	−10.729	39.142	15.146*
	(16.531)	(35.453)	(10.613)	(28.832)	(64.491)	(14.928)	(12.058)	(34.828)	(8.565)
Observations	238	194	432	238	194	432	241	194	435
Adjusted R2	0.495	0.590	0.524	0.487	0.594	0.518	0.806	0.911	0.812

The dependent variable is U.S. crude oil imports; all non−dummy variables are in log format. Standard errors in parentheses. *P<0.10, **P<0.05, ***P<0.01

Table 6: Robustness checks for the gravity model

Variables	WTO=1			FTA=1			OPEC=1		
	1993-2006	2007-2016	1993-2016	1993-2006	2007-2016	1993-2016	1993-2006	2007-2016	1993-2016
US GDP $	−0.604	−6.190***	−1.769***	1.986	0.652	3.947***	0.145	−6.576***	−0.981
constant	(0.640)	(1.159)	(0.357)	(2.198)	(0.994)	(0.360)	(0.947)	(2.318)	(0.724)
Exporters' GDP	0.315***	0.639***	0.288***	−0.678	−2.383***	−3.044***	1.087***	−0.817***	0.516***
constant	(0.078)	(0.099)	(0.066)	(2.100)	(0.420)	(0.266)	(0.314)	(0.242)	(0.164)
Distance	−1.677***	−1.934***	−1.695***	−2.938***	0.243	0.639***	−1.410***	0.795	−1.251***
	(0.124)	(0.137)	(0.093)	(1.097)	(0.240)	(0.187)	(0.460)	(0.779)	(0.352)
Contiguity	0.674	0.287	0.539*	−3.365	8.648***	10.343***			
	(0.574)	(0.319)	(0.297)	(2.711)	(0.917)	(0.677)			
Common language	0.126	−1.096***	−0.430***	−3.263***	4.311***	4.926***	1.716***	−2.261	0.554
	(0.171)	(0.224)	(0.160)	(1.254)	(0.508)	(0.490)	(0.317)	(1.561)	(0.605)
FTA	−0.708*	0.497***	0.181						
	(0.381)	(0.185)	(0.189)						
OPEC	1.470***	2.058***	1.788***						
	(0.189)	(0.237)	(0.142)						
Trade openness	−0.311**	−0.519***	−0.314**	−0.492	−2.341***	−3.114***	1.063**	−4.374***	−0.776
	(0.135)	(0.169)	(0.125)	(0.615)	(0.700)	(0.217)	(0.482)	(0.610)	(0.506)
Exchange rate	−0.049**	0.049*	0.02	0.194	0.675***	0.728***	−0.223***	−0.174***	−0.187***
	(0.023)	(0.028)	(0.018)	(0.342)	(0.085)	(0.056)	(0.078)	(0.044)	(0.049)
US arm sales	−0.001	0.071	0.029	0.003	0.02	0.004	0.116**	0.041	0.103*
	(0.048)	(0.046)	(0.034)	(0.029)	(0.058)	(0.027)	(0.059)	(0.094)	(0.056)
Freedom Index	0.091	0.379***	0.106**	0.059	0.222	0.095*	0.189**	1.181***	0.388***
	(0.070)	(0.070)	(0.054)	(0.111)	(0.165)	(0.056)	(0.093)	(0.129)	(0.104)
WTO				0.143		0.899***	−0.344	2.212***	0.17
				(0.125)		(0.163)	(0.226)	(0.792)	(0.325)
Constant	35.883*	198.345***	71.511***	0	55.720**	−28.233***	−13.403	236.330***	40.234*
	(19.090)	(34.831)	(10.566)	0.000	(26.133)	(6.937)	(24.955)	(71.022)	(22.322)
Observations	179	180	359	29	47	76	66	55	121
Adjusted R2	0.565	0.600	0.572	0.712	0.960	0.968	0.345	0.504	0.239

The dependent variable is U.S. crude oil imports; all non-dummy variables are in log format. Standard errors in parentheses. *P<0.10, **P<0.05, ***P<0.01. OPEC in FTA=1, and Contiguity and FTA in OPEC=1 regression are omitted because of collinearity

almost exclusively from Canada and Mexico for FTA partners. Interestingly, in the 1993-2006 sample, distance is negative (and contiguity is not statistically significant), but this result is reversed in the later time-frame (due to the increase in imports from Canada and Mexico). The exchange rate is statistically significant in this model, and the Freedom Index is statistically significant at the 10% level. This model also features the highest adjusted R-squared at 0.968.

The final specification presents results for those countries who are a member of OPEC. Across the entire sample, U.S. GDP is no longer statistically significant, as is the case for many variables that were statistically significant in the other models (common language, WTO member, trade openness). Indeed, the adjusted R-squared for this specification is the lowest of all models (0.239). U.S. arm sales are statistically significant, as is the Freedom House Index, indicating that the U.S. is more likely to import crude oil from OPEC members that it sales arms to, and those that have less freedom.

5. CONCLUSIONS

Crude oil is arguable the most important commodity in the world as it provides a large part of energy to the world. The United States is a major player in the market, importing and consuming a large share of crude oil. Therefore, it is important to investigate the variables that impact U.S. crude oil imports. Because the literature suggests that transportation costs and quality are important to crude oil trade flows, we use a gravity model for this analysis. We include the standard gravity variables, and also consider several factors related to trade. But, the main contribution to the literature is two parts: the specification of two variables related to political relations: U.S. arm sales and the level of freedom in the exporting country. Crude oil is much different than any other commodities, since it is heavily traded and is deemed a national security issue almost worldwide. In addition, we also test for a structural break in our data, with results indicating that the determinants of U.S. crude oil imports differ beginning around 2007.

After conducting several exercises in specification for the gravity model, we can make the following conclusions. First, distance is an important determinant for U.S. crude oil imports, with results indicating that as distance increases, imports to the U.S. decreases. Second, results indicate that U.S. GDP and oil imports are inversely related, which is due to the fall in U.S. crude oil imports over the last eight years. Contiguity is important for U.S. crude oil imports (since it imports so much from Canada and Mexico), but free trade agreements are not. Being an OPEC member leads to more imports of crude oil to the U.S., while a common language and trade openness are not. These factors combined with the negative relationship with freedom and U.S. crude oil imports, suggests that the U.S. imports a lot of oil from countries that have little or no cultural and political similarities. Finally, the econometric analysis across time-frames indicates that the U.S. is now in a different era then when it was the world's largest importer of crude oil.

REFERENCES

Alkathiri, N., Al-Rashed, Y., Doshi, T., Murphy, F. (2017), Asian premium or North Atlantic discount: Does geographical diversification in oil trade always impose costs? Energy Economics, 66, 411-420.

Alkhateeb, T., Mahmood, H., Sultan, Z. (2021), Role of oil price in fiscal cyclicality in Saudi Arabia. International Journal of Energy Economics and Policy, 11(2), 194-198.

Amin, S., Audry, N., Ulfat, A. (2021), The nexus between oil price shock and the exchange rate in Bangladesh. International Journal of Energy Economics and Policy, 11(2), 427-435.

An, H., Zhong, W., Chen, Y., Li, H., Gao, X. (2014), Features and evolution of international crude oil trade relationships: A trading-based network analysis. Energy, 74, 254-259.

Anderson, J., van Wincoop, E. (2003), Gravity with gravitas: A solution to the border puzzle. American Economic Review, 93, 170-192.

Dascal, D., Konstadinos, M., Tzouvelekas, V. (2002), An analysis of EU wine trade: A gravity model approach. International Advances in Economic Research, 8, 135-147.

Du, Y., Ju, J., Ramirez, C., Yao, X. (2017), Bilateral trade and shocks in political relations: Evidence from China and some of its major trading partners, 1990-2013. Journal of International Economics, 108, 211-225.

EIA. (2018a), China Surpassed the United States as the World's Largest Crude Oil Importer in 2017, Today in Energy. United States: Energy Information Administration.

EIA. (2018b), Petroleum and Other Liquids: Resource Document. United States: Energy Information Administration.

Endri, E., Rinaldi, M., Arifian, D., Saing, B., Aminudin, A. (2021), Oil price and stock return: Evidence of mining companies in Indonesia. International Journal of Energy Economics and Policy, 11(2), 110-114.

Energy Information Administration (EIA). (2006), Oil Market Basics. United States: Energy Information Administration.

Freedom House. (2018), Freedom in the World. United States: Freedom House.

Fuchs, A., Klann, N. (2013), Paying a visit: The Dalai Lama effect on international trade. Journal of International Economics, 91, 164-177.

Grant, K., Ownby, D., Peterson, S. (2006), Understanding today's crude oil and product markets. In: Policy Analysis Study. United States: Lexecon.

Hanson, K., Robinson, S., Schluter, G. (1993), Sectoral effects of a world oil price shock: Economy-wide linkages to the agricultural sector. Journal of Agricultural and Applied Economics, 18(1), 96-116.

Harri, A., Nalley, L., Hudson, D. (2009), The relationship between oil, exchange rates, and commodity prices. Journal of Agricultural and Applied Economics, 41(2), 501-510.

Heilmann, K. (2016), Does political conflict hurt trade? Evidence from consumer boycotts. Journal of International Economics, 99, 179-191.

Ji, Q., Zhang, H., Fan, Y. (2014), Identification of global oil trade patterns: An empirical research based on complex network theory. Energy Conversion and Management, 85, 856-865.

Kareem, F. (2013), Modeling and estimation of gravity equation in the presence of zero trade: A validation of hypotheses using Africa's trade data. In: Selected Paper Prepared for Presentation at the 140th EAAE Seminar, Perugia, Italy.

Kashcheeva, M., Tsui, K. (2015), Political oil import diversification by financial and commercial traders. Energy Policy, 82, 289-297.

Koo, W., Karemera, D., Taylor, R. (1994), A gravity model analysis of meat trade policies. Agricultural Economics, 10, 81-88.

Krane, J., Medlock, K. (2018), Geopolitical dimensions of US oil security. Energy Policy, 114, 558-565.

Mityakov, S., Tang, H., Tsui, K. (2013), International politics and import diversification. Journal of Law and Economics, 56, 1091-1121.

Organization of the Petroleum Exporting Countries (OPEC), (2017), Annual Statistical Bulletin. Baghdad: OPEC.

Piermartini, R., Yotov, Y. (2016), Estimating trade policy effects with structural gravity. In: WTO Staff Working Paper No. ERSD-2016-10.

Prentice, B., Wang, Z., Urbina, H. (1998), Derived demand for refrigerated truck transport: A gravity model analysis of Canadian pork exports to the United States. Canadian Journal of Agricultural Economics, 46, 317-328.

Prest, B. (2018), Explanations for the 2014 oil price decline: Supply or demand? Energy Economics, 74, 63-75.

Saghaian, S. (2010), The impact of the oil sector on commodity prices: Correlation or causation? Journal of Agricultural and Applied Economics, 42(3), 477-485.

Shepherd, B. (2013), Gravity Model of International Trade: A User Guide (An Updated Version), UN-ESCAP Secretariat, Bangkok, Thailand.

Silva, J.S., Tenreyro, S. (2006), The log of gravity. Review of Economics and Statistics, 88, 641-658.

Stockholm International Peace Research Institute (SIPRI). (2018), SIPRI Arms Transfers Database. Stockholm: SIPRI.

Summary, R. (1989), A political-economic model of U.S. bilateral trade. Review of Economic and Statistics, 71, 179-182.

Tinbergen, J. (1962), Shaping the World Economy: Suggestions for an International Economic Policy. New York: The Twentieth Century Fund.

UN Comtrade. (2018), Trade Database. United Nations.

World Bank. (2018), GDP (Current US). Washington, DC: World Bank.

Zhang, H., Ji, Q., Fan, Y. (2015), What drives the formation of global oil trade patterns? Energy Economics, 49, 639-648.

Zhang, H., Xi, W., Ji, Q., Zhang, Q. (2018), Exploring the driving factors of global LNG trade flows using gravity modelling. Journal of Cleaner Production, 172, 508-515.