Iran. Econ. Rev. Vol. 20, No. 2, 2016. pp. 203-224

A Panel Data Analysis of South Korea's Trade with OPEC Member Countries: The Gravity Model Approach

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Received: 2016/4/5 Accepted: 2016/6/18

Abstract

This paper explains bilateral trade patterns between South Korea and thirteen OPEC member countries over the period 1980-2014 using a gravity model. The estimation results show that the gravity equation fits the data reasonably well. We confirmed the existence of long term relationships between the bilateral trade flows and the main components of gravity model - GDP, income (GDP per capita), the difference in income, exchange rate, the openness level, distance and WTO membership – through the Fixed effects (FE), Random effects (RE) and the FMOLS approaches. The findings show that the trade pattern between South Korea and OPEC member countries relies on the Heckscher-Ohlin (H-O) theory, thus being explained by difference in factor endowments such as energy resources and technology. It is also found out that South Korea – OPEC trade is well explained by the factors that influence the energy security of South Korea such as oil reserves, transportation costs and political stability.

Keywords: Gravity Model, Bilateral Trade, South Korea, OPEC, Panel Data.

JEL Classifications: C21, C23, F10, F14.

1. Introduction

Over the last decades, modeling bilateral trade has received considerable attention among academic researchers. They have tried to explain the structure of trade flows between nations or a group of countries. One of the most popular international trade models, extensively has been used to formulate trade flows between countries, is the gravity model of trade, which was firstly introduced by Tinbergen (1962) and Poyhonen (1963) based on

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this idea that bilateral trade flows between two countries depends on national incomes and bilateral distance.

In this paper, we try to use a gravity model to investigate the bilateral trade between South Korea and the 13 OPEC member countries during the period 1980 to 2014. The choice of these countries for this study is also motivated by the fact that South Korea is one of the largest importers of fossil fuel energy, while OPEC member countries are the main exporters of this kind of energy in the world. This fact can shape a distinctive trade pattern between South Korea and these 13 countries, raising the question whether the gravity model also fits the unique trade structure. Hence, it is scientifically and economically meaningful to applying the gravity model to investigating the South Korea-OPEC trade flows.

Although the trade flow of South Korea has drawn some attention from researchers such as Almansoori (2014), Chiou-Wei & Zhu(2002), Feenstra et al.(1999), Goh et al.(2013), Sharma(1989) and Sohn(2005), we do not find any study, considering the analysis of South Korean bilateral trade with OPEC member countries through a gravity model. Therefore, this study leads to make new research results for scholars and policy makers.

The remainder of this paper is structured as follows: Section 2 discusses South Korea-OPEC trade pattern. Section 3 provides a brief literature review of the gravity model. Data and methodology are discussed in section 4. Section 5 presents the research results and finally, section 6 concludes with a discussion and directions for further research.

2. South Korea-OPEC Trade Pattern

The South Korean economy is characterized by a significant dependence on energy imports (nearly 97% of its total primary energy consumption). In 2013, this country was the fifth biggest oil importer worldwide with about 64% of its oil coming from OPEC member countries (Almansoori, 2014). In fact, energy can be considered as the most traded commodity and also the main cause of the trade volume growth between South Korea and the OPEC member countries in the recent decades. Historically, by dominating the global oil market by OPEC after the collapse of the Bretton Woods system in the early of the 1970s, many fossil fuel energy consuming countries, such as South Korea, have expanded their trade flows with the members of this organization to provide and import their fossil fuel energy requirements. Even though members of this organization faced with many unusual economic and political circumstances, such as Iran's Islamic Revolution in 1979, Iraq-Iran war in 1980, Iraq-Kuwait war in 1990, Indonesia's financial crisis of 1997-8, Venezuelan general strike of 2002-3, Iraq-U.S. war in 2003, Arab Spring in 2011, their bilateral trade flows with South Korea have grown rapidly over the last decades. According to the KOSIS[1] data, trade volume between South Korea and the OPEC member countries has grown nearly 1763.1% over the period 1980-2014. The following table reports the trade growth between South Korea and the 13 member countries of OPEC. It can be seen that South Korea's major trading OPEC member partners include Saudi Arabia, Kuwait and Iran in 1980, and Saudi Arabia, Qatar and Indonesia, respectively in 2014.

Table1: Bilateral Trade between South Korea and the OPEC Member Countries, 1980 -2014 (Thousand $)

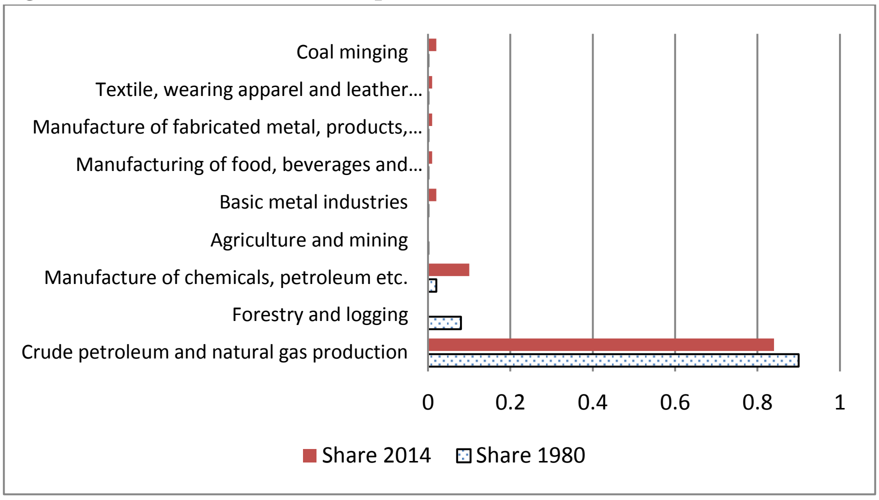
Countries	**Year**		**Growth (%)**
	1980	**2014**	
UAE	190507	23405884	12186.1
Angola	8155	1949814	23809.4
Algeria	9827	3365389	34146.3
Ecuador	42310	1154035	2627.5
Indonesia	850162	23626916	2679.1
Iraq	34589	8484839	24430.4
Iran	1260807	8740362	593.2
Kuwait	2002340	18867904	842.2
Libya	174152	1636410	839.6
Nigeria	124423	4474070	3495.8
Qatar	7491	26627541	355360.4
Saudi Arabia	4234517	44982047	962.2
Venezuela	54244	250820	362.3
OPEC	8803017	144160147	1537.6

Source: Authors' compilation from KOSIS

In the case of imports, as of 2014, more than 80% of South Korea's imports from OPEC are related with energy resources such as crude oil and natural gas. Manufacturing of chemicals and petroleum is the second largest sector in 2014, while forestry and logging products were placed second in 1980.

1. Korean Statistical Information Service

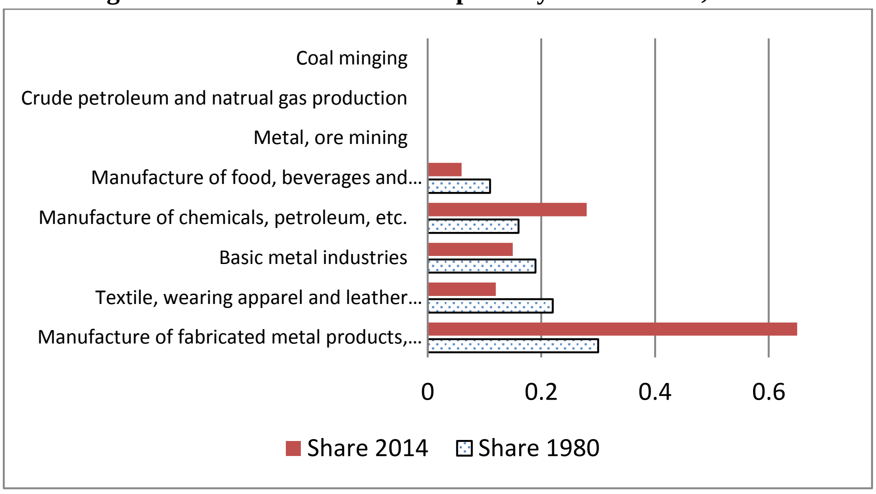
Fig.1: Sectoral Share in Total Imports from OPEC to South Korea,1980-2014



Source: UN Comtrade Database and Authors’ calculation

About the export flow between South Korea and the OPEC member countries, it can be noted that since 1980, the structural pattern of South Korea's exports to OPEC has shown changes, particularly in accelerated growth of industrial suppliers and high-tech products and decreasing share of consumer goods such as textile and food. The machinery and electronic products account for 60 percent of total South Korea's exports to OPEC and the share of chemical products is more than 20% of South Korea's total exports to OPEC. On the contrary, the share of textile and food products decreased from 20% and 5% in 1980 to 5% and 2% in 2014, respectively.

Fig.2: Sectoral Share in Total Exports by South Korea, 1980-2014



Source: UN Comtrade Database and Authors’ calculation

3. Literature Review of the Gravity Approach

There are a great number of studies that investigated bilateral trade flows through the Gravity model, which is a well-known tool to model international trade (Brun, Carrere, Guillaumont, & De Melo, 2005; Liu & Xin, 2011; Novy, 2013; Redding & Venables, 2004; Ulengin et al., 2015). The first well-known study exploring trade flows goes back to Jan Tinbergen's paper "Shaping the world economy: suggestions for an international economic policy" in 1962. He believed that based on the Newton's gravity rule, the trade between two countries can be a function of their economic sizes and distance between them (Tinbergen, 1962). The Tinbergen's theoretical foundation of this model was improved by Anderson(1979), Bergstrand (1989), Brocker(1989), Deardorff(1998) and Linnemann(1966).

By the time, scholars have developed the empirical econometric approaches of the gravity model by using a number of real and dummy variables in regards to trade flows of various countries. For instance, Byers et al.(2000) applied a parsimonious gravity model for three Baltic countries of Estonia, Latvia and Lithuania after the collapse of the Soviet Union. Their findings stated that the trade flows of these nations were not only reduced, but also shifted to the members of the former Soviet Union. Porojan (2001) tried to find trade flows-spatial effects nexus through a gravity model for the European Union and some of its potential members. In another study, Martinez-Zarzaso (2003) evaluated the effects of preferential agreements on the bilateral trade flows among 47 countries in several economic blocs and areas during 1980-1999.

Papazoglou(2007) attempted to explore potential trade flows for Greece to the EU member states by using a gravity model. His finding depicted actual exports of Greece fall short of potential ones, while the opposite is true for Greek imports. Okubo(2007) investigated the trading system of the Japanese Empire using border effect analysis in a gravity model from the 1910s through the 1930s. His finding showed steadily trading bloc border effects in this period. Xuegang et al.(2008) used the three explanatory variables GDP, GDP per capita and Shanghai Cooperation Organization (SCO) to construct a gravity model for Xinjiang's bilateral trade. Their result illustrated that all the three variables affect the Xinjiang's bilateral trade. Ekanayake et al.(2010) investigated the trade diversion effects of the regional trade agreements in Asia on intra-regional trade flows by using a gravity model and annual data for 19 Asian countries during 1980-2009. The findings represented the negative sign of ECO and positive signs of ASEAN, BA and SAARC RTAs. Chen and Novy(2011) applied a gravity model to find out the trade integration across manufacturing industries in European Union countries. They concluded that substantial technical barriers to trade in specific industries are the most important trade barriers. Ulengin et al. (2015) developed two gravity models to analyze Turkish textile exports to 18 selected EU countries between 2005-2012. Their result proved the fact that the quota limitations are against Customs Union regulations.

Some earlier studies were applied a gravity model in the case of our study, i.e. South Korea. Sohn(2005) tested a gravity model to find out the trade pattern of South Korea with its 30 major trading partners in 1995. His results showed that South Korea's trade has the Heckscher-Ohlin pattern. Keum(2010) applied a gravity model to explore the relationship between tourism flows and trade volume in South Korea. His empirical findings provided evidence supporting applicability of the gravity model to the flow of trade and tourism. Lee(2011) analyzed the bilateral trade of South Korea with its 50 major trading partners using a gravity model in 2008. The results reported that there is a wide range of gaps between the actual bilateral trade and the potential trade volume between North Korea and South Korea. Kim(2011) estimated a gravity model to find out what determined the trade flow of South Korea with Japan and the U.S. The results of estimation by random effects showed that trade affected GDP and R&D positively. Kang (2014) investigated South Korean trade potentials in Africa through a gravity model over the period of 2006-2011. The results of this study proved that tariffs, human networks and trade structure have significant impacts to exports of South Korea to Africa.

Overall, it can be seen that there has not been a serious attempt to examine South Korea-OPEC bilateral trade. Hence, this paper would provide new and useful results in order to find out how various factors can affect the bilateral trade between South Korea and the OPEC member countries.

4. Data Description and Methodology

4.1 Dataset Description

This study covers bilateral trade between South Korea and OPEC which consists of 13 member countries (Algeria, Angola, Ecuador, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela)[1] over the period 1980 to 2014. The variables used in this study contain trade volume (sum of import and export) between South Korea and the 13 OPEC member countries in thousand U.S. dollars, GDP and GDP

1. Over the last decades, the number of OPEC countries has been changed. But these 13 countries have been chosen based on the OPEC website information in 2016 : http://www.opec.org/opec_web/en/about_us/25.htm

per capita in thousand U.S. dollars, distance between South Korea and the 13 OPEC member countries in kilometers and the openness level (sum of exports and imports of goods and services measured as a share of gross domestic product) in percent. The source of the data on trade volume and bilateral exchange rate is Korean Statistical Information Service (KOSIS, 2015). The data on GDP, GDP per capita and the openness level are collected from World bank, (2015) and the World Economic Outlook Database(IMF, 2015). Data for distance between countries were gathered from the GeoDist database (CEPII, 2015)[1] which is based on the great circle distance between capital cities. Furthermore, all the time-variant series are nominal and transformed in to natural logarithms, based on the advantages of this form than using the level of variables(Wooldridge, 2013).

Table 2: The Variables of Model

Variables	Definition	Unit
Trade	Trade volume between S. Korea and OPEC member countries	Thousand US $
Y	GDP in S. Korea and OPEC member countries	Thousand US $
YP	GDP per capita in S. Korea and OPEC member countries	Thousand US $
OPEN	The openness level in S. Korea/ the openness level in OPEC member countries	%
EX	Bilateral exchange rate	-
DIS	Distance between capitals of S. Korea and OPEC member countries	Kilometers
WTO	Dummy variable taking a value of one if S. Korea and a trading partner belong to the WTO	Dummy (0/1)

Source: Authors' compilation.

4.2 Model Specification

The earliest form of the gravity model which was introduced by Tinbergen(1962) has the following structure:

$$lnExport_{ij} = \beta_0 + \beta_1 lnY_i + \beta_2 lnY_j + \beta_3 lnDIS_{ij} + \varepsilon_{ij}$$

Where the export volume of country i to j ($lnExport_{ij}$) has a relationship with the GNP in country i (Y_i) and in country j (Y_j), meanwhile the distance between countries i and j (DIS_{ij}) as a proxy for transportation cost.

Over the years, numerous scholars have developed the above basic form by using other real or dummy variables. For instance, Linnemann (1966) extends the gravity model and introduces population size of countries i and j, and the artificial trade resistance factor. Frankel(1992) extends the basic form further income (GDP per capita). Pfaffermayr (1994) adds foreign direct investment as a variable affecting trade flows between countries. Chen

1. the French Centre d'Etudes Prospectives et d'Informations Internationales

& Wall (1999) uses the trade policy index or Nguyen (2010) includes bilateral exchange rate and regional trade preference. Anderson & Wincoop (2003) define the multilateral resistance factors (MRF_s) such as language, remoteness etc. Guttmann & Richards (2004) include the openness level as a variable, influencing on trade between countries.

In this study, we employ a gravity model, recently developed by Narayan & Nguyen(2016) to model bilateral trade flow between South Korea and OPEC countries. Their model in our case can be written as follows, comprising only the time variable variables as:

$$lnTRADE_{ijt} = \delta_1 + \delta_{2a} \ln\left(Y_{it}Y_{jt}\right) + \delta_{2b} \ln\left(YP_{it}YP_{jt}\right) + \delta_{2c} \ln\left(DYP_{ijt}\right) + \delta_3 \ln EX_{ijt} + \delta_4 ln\, OPEN_{ijt} + \varepsilon_{ijt}$$

Where TRADE represents trade volume between South Korea (country i) and a trading partner (country j) at specific time t. $Y_{it}Y_{jt}$ indicates the economy size of South Korea and trading partner j at time t. Moreover, $YP_{it}YP_{jt}$ shows income (GDP per capita) for South Korea (country i) and a trading partner (country j). Here, DYP_{ijt} denotes the difference between South Korea's GDP per capita and country j's GDP per capita. Furthermore, EX represents the bilateral exchange rate and OPEN shows the openness levels at time t (In our model, it is constructed as the South Korea's trade openness level divided by country j's trade openness level).

Narayan & Nguyen(2016) argues that to avoid of the multicollinearity problem, it is better breaking the above gravity model into three various models in which GDP and income variables are considered separately in each. Following their idea, the three following gravity model will be applied in our study:

Model I :

$$lnTRADE_{ijt} = \delta_1 + \delta_{2a} \ln\left(Y_{it}Y_{jt}\right) + \delta_3 \ln EX_{ijt} + \delta_4\, lnOPEN_{ijt} + \varepsilon_{ijt}$$

Model II :

$$lnTRADE_{ijt} = \delta_1 + \delta_{2b} \ln\left(YP_{it}YP_{jt}\right) + \delta_{2c} \ln\left(DYP_{ijt}\right) + \delta_3 \ln EX_{ijt} + \delta_4\, lnOPEN_{ijt} + \varepsilon_{ijt}$$

Model III :

$$lnTRADE_{ijt} = \delta_1 + \delta_{2c} \ln\left(DYP_{ijt}\right) + \delta_3 \ln EX_{ijt} + \delta_4\, lnOPEN_{ijt} + \varepsilon_{ijt}$$

The above three gravity equations only comprise time-variant variables. Similarly to other gravity model, our models have some time-invariant variables, i.e. distance and multilateral trade agreement WTO:

Time invariant variables: $\delta_5 lDIS_{ij} + \delta_6 WTO$

Here, Dis_{ij} indicates the distance between capitals in South Korea (country i) and a trading partner (country j). Meanwhile, WTO is a dummy variable which is captured bi-nominal variables. It takes a value of 1 if South Korea and a trading partner belong to the WTO or takes 0 otherwise.

The expected signs of coefficients in our gravity models can be explained as in Table 3.

Table3: Expected Signs of the Variables

Variable	Type	Expected sign
Trade	Time-variant	Positive
$Y_{it}Y_{jt}$	Time-variant	Positive
$YP_{it}YP_{jt}$	Time-variant	Positive
DYP_{ijt}	Time-variant	Ambiguous
EX	Time-variant	Positive
OPEN	Time-variant	Positive
Dis	Time-invariant	Negative
WTO	Time-invariant	Positive

Source: Authors' compilation.

According to the theoretical framework of the gravity model, it is expected that economy size and income would have positive impacts on trade volume and encourage trade between South Korea and its trading partners, including 13 members of OPEC. The influence of the third income measure (DYP_{ijt}) may be ambiguous. Its coefficient can have a positive sign, if countries have the H-O bilateral trade pattern (Baskaran, Blochl, Bruck, & Theis, 2011), while the negative sign of this variable can appear under Linder hypothesis(Linder, 1961). The coefficient for the bilateral exchange rate is expected to be positive (for instance, any increase in the South Korean Won, leads to an increase in trade flows between this country and the trading partner). It is also expected that the coefficient of the openness level may be positive. In the case of time-invariant variables, the coefficient of DIS is expected to bear a negative sign as distance shows the transportation cost between South Korea and a trading partner. Since it is widely believed that countries' accession and membership to the WTO is a milestone in increasing trade volume, hence its coefficient is expected to be positive in our gravity model.

5. Results and Discussion

5.1 Panel Cross-Section Dependence Test

Before applying panel unit root tests, cross-section dependence should be tested to find out whether the sample data are cross sectional dependent or independent. Otherwise, based on Breusch and Pagan (1980) and

Pesaran(2004), the results of our estimation would be biased and inconsistent. According to the time and cross sections in our study, the Pesaran(2004) residual cross-section dependence (CD) test is computed based on the pairwise correlation coefficients $\hat{\rho}_{ij}$ as below:

$$CD = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N} \sum_{j=i+1}^{N} \sqrt{T_{ij}} \hat{\rho}_{ij}$$

Based on the result of the CD Pesaran(2004) test, shown in Table 4, the null hypothesis (No cross-section dependence in residuals) can be strongly rejected at the 5% level. It implies that all series have strong evidence for cross-sectional dependence.

Table 4: Pesaran (2004)’s CD Test

Variables	Pesaran’s CD test	Prob.
LTRADE	35.87	0.00
LYY	46.96	0.00
LYPYP	49.38	0.00
LDYP	18.89	0.00
LEX	22.89	0.00
LOPEN	9.73	0.00

Source: Authors’ compilation from Eviews 9.0

The result of the cross-section dependence test shows which kind of panel unit root test is appropriate to apply. For cross-sectional independence in panels, using LLC test and PP test are more convenient, because they assume cross-sectional independence. Based on our finding which depicts cross-sectional dependence of our series, the most proper unit root test is the cross-sectional augmented ADF (Pesaran, 2007).

5.2 Panel Unit Root Tests

In order to determine the stationarity of all the underlying time series data in a cross sectional dependent panel, we carry out the CADF panel unit root test (Pesaran, 2007) for the variables at levels and first differences.

Pesaran (2007) for a panel with N cross-sectional units and T time series observations suggests a simple linear heterogeneous model as:

$$Y_{i,t} = (1-\delta_i)\mu_i + \delta_i Y_{i,t-1} + u_{i,t} \quad i = 1, \dots, N \quad t = 1, \dots, T$$

And suggests a test based on the t-ratio in the following cross-sectional ADF regressions:

$$\Delta Y_{i,t} = a_i + b_i Y_{i,t-1} + c_i \overline{Y}_{t-1} + d_i \Delta \overline{Y}_t + \epsilon_{i,t}$$

In the above equation, $\overline{Y}_t = \frac{1}{N}\sum_{i=1}^{N} Y_{i,t}$ and $\Delta\overline{Y}_t = \frac{1}{N}\sum_{i=1}^{N} \Delta Y_{i,t}$. Furthermore, $\epsilon_{i,t}$ indicates the regression error.

By applying this unit root test through the software, the results are calculated as:

Table 5: Panel Unit Root Test Results

Variable	Pesaran's CADF	H0	Stationary
LTrade	19.55 [0.81]	Accept	No
D(LTrade)	325.49[0.00]	Reject	Yes
LYY	23.02[0.63]	Accept	No
D(LYY)	200.83[0.00]	Reject	Yes
LYPYP	2.94[1.00]	Accept	No
D(LYPYP)	232.52[0.00]	Reject	Yes
LDYP	32.60[0.17]	Accept	No
D(LDYP)	212.27[0.00]	Reject	Yes
LEX	38.94[0.04]*	Accept	No
D(LEX)	256.54[0.00]	Reject	Yes

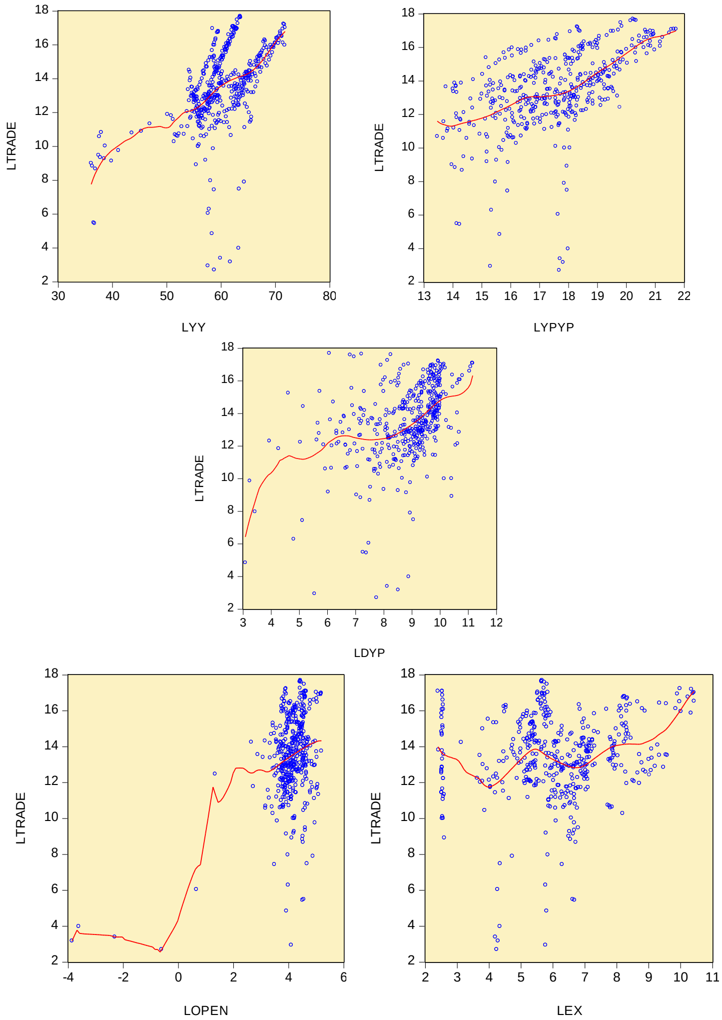
Note: Numbers in brackets indicate p-values , * is statistical insignificance at 1% level

Source: Authors' compilation from Eviews 9.0

The reported p-values in the above table imply that all the series is non-stationary at levels by assuming a significance level of 5% (except for exchange rate (LEX) at the 1% level) which means accepting the null hypothesis representing that the series contain a panel unit root, and stationary (rejecting the null hypothesis) at their first difference which stands for the integration at I(1).

According to Chang(2015), scatterplots drawing can make a possibility to better understand the integrity of variables. Based on the Kernal fit lines, it is obvious that the relationship between trades and all the three LYY, LYPYP and LDYP are positive. That means LTRADE increases with higher level of higher LYY, LYPYP and LDYP. In addition, the figure depicts the positive relationship between LTRADE and LOPEN, while there is not any obvious relationship between LTRADE and LEX.

Fig.3: Scatterplots of L-Trade Against Variables



Source: Authors' compilation from Eviews 9.0

5.3 Pedroni Panel Cointegration Test

Since the evidence is found that the series are stationary at the first difference level, the Pedroni panel cointegration test can be applied for a group of variables where all series are I(1) to find out whether there is any long-run equilibrium relationship between the series (Taghizadeh Hesary, Rasoulinezhad, & Kobayashi, 2015). The results are presented in the following Table 6. From the results, by considering all the panel, group and weighted statistics, it indicates that the most statistics have p-value less than 0.05 and hence, the majority of the all statistics tests can significantly reject the H0 of no cointegration at the 5% significance level. In sum, it can be concluded that there is an evidence of a long run relationship between variables in all our three models.

Table6: Pedroni Panel Cointegration Test Results

		Statistic	Prob.	Weighted statistic	Prob.
Model I	Panel v-statistic	1.05	0.14	0.51	0.30
	Panel rho-statistic	-2.89*	0.00	-2.02	0.02
	Panel PP-statistic	-4.36*	0.00	-3.97*	0.00
	Panel ADF-statistic	-3.94*	0.00	-4.27*	0.00
	Group rho-statistic	-1.64*	0.05	-	-
	Group PP-statistic	-4.49*	0.00	-	-
	Group ADF-statistic	-4.91*	0.00	-	-
Model II	Panel v-statistic	1.53**	0.06	0.79	0.21
	Panel rho-statistic	-4.36*	0.00	-2.81*	0.00
	Panel PP-statistic	-5.81*	0.00	-4.74*	0.00
	Panel ADF-statistic	-5.13*	0.00	-4.55*	0.00
	Group rho-statistic	-2.20*	0.01	-	-
	Group PP-statistic	-5.56*	0.00	-	-
	Group ADF-statistic	-5.31*	0.00	-	-
Model III	Panel v-statistic	0.85	0.19	-0.39	0.65
	Panel rho-statistic	-2.14*	0.01	-0.91	0.17
	Panel PP-statistic	-4.14*	0.00	-2.62*	0.00
	Panel ADF-statistic	-3.99*	0.00	-2.79*	0.00
	Group rho-statistic	-1.42**	0.07	-	-
	Group PP-statistic	-4.57*	0.00	-	-
	Group ADF-statistic	-4.49*	0.00	-	-

Note: (*) shows statistical significance at the 5% level.

Source: Authors' compilation from Eviews 9.0

5.4 Gravity Model Estimation

After applying the cointegration test and finding out that there is a long run relationship between series in all our three gravity equations, the three panel data estimation approaches, i.e. fixed effect (FE), random effect (RF) and fully modified OLS (FMOLS) are applied to explore the coefficients of our all variables. Due to this fact that there is not a similar view to the estimation of panel co-integration (For instance, Pedroni(1996, 2001) recommends the fully modified OLS (FMOLS) estimator. Cheng & Wall(2005) and Anderson & Wincoop(2003) suggest the fixed effects (FE) or Soren et al.(2014) propose the random effects (RE), because FE does not allow for the time-invariant variables in a gravity model. Fidrmuc(2009) believes that since many macroeconomic variables like GDP are most likely I(1), there is not any problem to use fixed or random effects estimator and their results are similar to the fully modified OLS.) , therefore we apply all these three panel estimators to find and compare results. It should be mentioned that the coefficients for the time-invariant variables cannot estimate by the FE estimator. The findings are reported in Table 7.

Table 7: The Gravity Model Estimation

	Variables	FE	RF	FMOLS
Model I	LYY	0.07(0.00)	0.16 (0.00)	0.36 (0.00)
	LEX	-0.06(0.40)	0.14 (0.03)	-0.36 (0.00)
	LDIS	-	-1.85 (0.05)	-
	LOPEN	1.07(0.00)	1.15 (0.00)	0.48 (0.00)
	WTO	-	0.91 (0.00)	0.15 (0.00)
Model II	LYPYP	0.88 (0.00)	0.83 (0.00)	0.86 (0.00)
	LEX	-0.10 (0.13)	-0.04 (0.51)	-0.11 (0.00)
	LDIS	-	-2.08 (0.02)	-
	LOPEN	1.25 (0.00)	1.24 (0.00)	1.25 (0.00)
	WTO	-	0.35 (0.04)	0.28 (0.00)
Model III	LDYP	0.50 (0.00)	0.50 (0.00)	0.49 (0.00)
	LEX	0.08 (0.23)	0.10 (0.14)	0.16 (0.00)
	LDIS	-	-2.90 (0.00)	-
	LOPEN	1.15 (0.00)	1.15 (0.00)	1.18 (0.00)
	WTO	-	1.47 (0.00)	1.46 (0.00)

Source: Authors' compilation from Eviews 9.0

As it can be seen, the basic features of gravity model estimations are very similar across all three estimators. The estimation results of "Model I" confirm that GDP, the openness level and WTO membership have a highly significant positive impact on South Korea–OPEC bilateral trade, while distance negatively influences on the trade volume.

The "Model II" and "Model III" estimation findings depict that income (GDP per capita), difference of income (DYP), the level of openness and WTO membership increase the bilateral trade volume between South Korea and the 13 OPEC member countries, while similar to the first model estimation result, distance has a significant negative impact on the trade volume.

In the case of joint GDP, the results reveal that a 1% increase in the joint GDP in South Korea and the OPEC member countries raises the bilateral trade volume by approximately 0.19%. Joint income (GDP per capita) has a stronger positive influence on the South Korea – OPEC bilateral trade. The results show that the bilateral trade between these countries is boosted up about 0.85% with a 1% increase in the joint GDP per capita. Moreover, the effect of the difference between incomes (DYP) on trade is positive and significant. A 1% increase in DYP leads to a 0.5% increase in the bilateral trade volume between South Korea and the 13 OPEC member countries. This result is in line with the H-O theory which argues that nations would trade more if their factor endowment is different. In addition, our result does not support the Linder(1961)'s hypothesis who predicts a negative sign of DYP and believes on the impact of income similarities of countries on trade flow.

The findings of all the three model estimations provide evidence of a strong positive effect of the level of openness on the South Korea –OPEC bilateral trade. A 1% increase in the openness level raises the trade volume by an average of 1.1%[1]. The coefficient of WTO membership is estimated at an average of 1.48% [=Exp(0.91+035+1.47)-1] by RF estimator, compared to an average of 0.87% [=Exp(0.15+0.28+1.46)-1] by FMOLS. This indicates that trade volume increases by nearly 1.17%[2] when South Korea trades with WTO member countries from OPEC.

In the case of distance as a proxy of transportation cost, the negative sign of its coefficient, estimated by random effect (RE), represents that with geographical distance has a negative impact on bilateral trade between South Korea and the OPEC member countries. A 1% increase in this variable decreases the trade volume by an average of 2.27%[3].

In regards to the bilateral exchange rate, it is found to give mixed findings among our three models and estimation approaches. Its estimated coefficients by the FE estimator are not statistically significant. By RE estimating, the bilateral trade exchange rate only appears statistically significant and positive at the 5% level in the first model. Finally, we find significant negative coefficients of this variable by estimating the Model I and II through the FMOLS, while by considering the Model III estimation, the bilateral exchange rate has a positive significant impact on the trade volume between South Korea and the OPEC member countries. However, according to the theoretical believe and also the scatter plot diagram (Fig. 3), we consider the results that show the positive impact of bilateral exchange rate on the South Korea-OPEC trade volume. The positive coefficients for this variable are 0.14 and 0.16, respectively, means than by 1% depreciation of the South Korean Won against the OPEC member countries' currencies will increase the bilateral trade volume by nearly 0.15%[4].

6. Conclusion and Policy Implications

This study mainly investigates the impacts of GDP, GDP per capita, differences of GDP per capita, bilateral exchange rate, the openness level, distance and WTO membership on the South Korea – 13 OPEC member countries bilateral trade through the estimations of a gravity model from 1980 to 2014. Following Narayan & Nguyen (2016), we develop three gravity model equations to avoid any multicollinearity problem. The estimations of these equations are done by three panel approaches, i.e. fixed effect, random effects and the fully modified OLS.

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1. It is calculated as average of 1.07,1.15,0.48,1.25,1.24,1.25,1.15,1.15 and 1.18.
2. It is calculated as the average of 1.48% and 0.87%.
3. It is calculated as the average of -1.85, -2.08 and -2.9.
4. It is calculated as the average of 0.14 and 0.16.

Our estimation results are in line with the opinion of Fidrmuc(2009) about similarity of estimators' results for panel co-integration. Our results reveal that the basic features of gravity model estimations, except for the bilateral exchange rate, are very similar across all three estimators, i.e. FE, RE and FMOLS.

The empirical results show that an increase in GDP implies increase trade flow between South Korea and the OPEC member countries. Furthermore, the positive effect of income on the South Korea- OPEC members' bilateral trade is higher than the positive effect of GDP. In addition, our results prove the H-O theory, when the difference in income has a positive influence on the South Korea-OPEC trade volume. It means that South Korea with the 13 OPEC member countries trade more if their factor endowments are not the same. We also found the positive impact of the openness level and WTO membership on the bilateral trade volume, while the results reveal that trade-distance nexus is negative for these countries.

In regards to the bilateral exchange rate, we found mixed findings among our three models and estimation approaches. However, according to the theory and also the scatter plot diagram (Fig. 3), we consider the results that reveal the positive impact of bilateral exchange rate on the South Korea-OPEC trade volume. In other words, depreciation of the South Korean Won against the OPEC member countries' currencies will increase the bilateral trade volume.

All in all, we confirmed that the gravity model explains well the trade flows between South Korea and the OPEC member countries. Among explanatory variables, the GDP size, income level and geographical distance showed a particularly strong relationship with the trade flows. When it comes to trade flows from South Korea to the OPEC member countries, the strong effect of income level is explained by the high share of valuable goods in trade flow. The income level indicates the level of economic developments as well as the size and quality of consumer markets. South Korea's exports are mainly consumed by high-income economies or industrial suppliers. Therefore, the more developed and larger markets are associated with the greater volume of trade with South Korea. However, the trade flows from OPEC members to South Korea need to be explained from a different angle. The majority of imports of South Korea from OPEC members are energy resources, in particular crude oil. Our results are of special meaning because it supports the argument that a specific type of trade flows, heavily concentrated in energy-related products (particularly crude oil) can also be explained by the fundamental components of gravity model. The findings also provide special implications on energy trade and polices of South Korea and OPEC member countries. Oil import countries such as South Korea have focused on reliable supply of energy resources at reasonable prices in formulating energy policies (Almansoori, 2014). To this end, the oil-importing countries would like to choose oil-exporters that are geographically close, have abundance oil deposit and a safe political environment. This tendency results in the formation of community structure of the global oil trade. Ji et al. (2014) showed, through their network analysis, that the global oil trade network can be divided into three trading blocs that correspond to three main oil producing and consuming areas, respectively, including 'South America-West Africa-North America' trading bloc, 'the former Soviet Union-North Africa-Europe' trading bloc', and 'the 'Middle East-Asian-Pacific region' trading bloc to which South Korea is belong. Our empirical findings strongly support this argument. The GDP size of OPEC member countries is associated with the volume of oil production and deposit. The geographical distance captures transportation costs and security. The income level indicates economic developments and the quality of institution including political risks (Benassy-Quere, 2007). Thus, the difference among OPEC members in trade volume with South Korea is explained by difference in GDP, distance and income level that correspond to South Korea's energy police needs. From the variable summary for each OPEC members (see Appendix 1), we can easily conclude that top oil exporters to South Korea are close in distance and have relatively high income and great GDP size. Nevertheless, we can still enough room to expand trade of other oil exporters such as Iran with South Korea. According to our findings, they could facilitate exports to South Korea by exerting policy efforts focusing on the key factors in determining oil trade partners, for instance promoting economic development, enhancing political stability and improving transportation system. Furthermore, South Korea's recent policy direction to diversify oil import source and energy fuels (Almansoori, 2014) to mitigate the risks of high dependency on the several Middle Eastern countries would be also an opportunity to non-middle east exporting nations such as Angola, Nigeria and Algeria. Beyond the basic components of gravity model, general economic ties or diplomatic relationships also likely to contribute the formation of oil trade pattern. For instance, Iraq is developing close trade relationships with the United States, belonging to 'South America-West Africa-North America' trading bloc as a Middle Eastern country. In this sense, strengthening economic tie and partnership with South Korea and oil exporters cannot be overstated in formulation and implementation of strategic trade policies.

However, it is noticeable that our exercise has limitations given the changing dynamics of global energy markets. As a low oil price has prolonged, the trade pattern between South Korea and OPEC member country possibly turn into a different phase. The development of alternative energy in South Korea could affect the trade relationships between two parts. However, these issues would be a different arena of study that remains for further research works later.

Acknowledgements

The authors gratefully acknowledge the anonymous reviewers who dedicated their time and expertise to reviewing our manuscript and their suggestions helped improve and clarify this manuscript. Any opinions or recommendations expressed in this material are those of the authors and do not necessarily reflect those of MOSF.

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Appendix

Appendix1: Average of Variables, 1980-2014

	DIS (Km)	EX	YPYP (Mln $)	YY (Mln $)	Trade (Mln $)	OPEN (%)	DYP (Mln $)
OPEC	9521	1828	159	3.35E+29	3851038	69.83	11189
UAE	7111	262.1	434	4.76E+26	7605474	98.68	21629
Angola	12519	963	32	3.11E+27	442583	109.60	10311
Algeria	10938	825	40	5.21E+27	574366	56.37	9302
Ecuador	15377	742	41	4.87E+25	456797	48.17	9382
Indonesia	4324	9173	22	2.48E+30	8966372	55.17	10736
Iraq	7446	66	51	6.93E+28	1896272	69.04	8488
Iran	6656	1308	48	1.77E+30	4415766	39.54	9620
Kuwait	7341	2424	36	3.19E+23	2002340	112.64	18909
Libya	9972	222	97	3.16E+25	498718	76.62	6488
Nigeria	11923	1043	15	1.86E+28	929447	51.90	11199
Qatar	7238	12	641	1.87E+26	5219158	81.07	25685
Saudi Arabia	7852	259	175	8.98E+26	13784092	75.62	4144
Venezuela	15074	5586	90	3.40E+26	345937	49.79	7129

Source: Authors' compilation