Analysis of the Comparative Advantage of Crude Oil Production: Evidence from Panel Data Econometrics

Osama Mohammed A. Elsalih

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Prof. Dr. Ali Hakan Ulusoy
Acting Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy in Economics.

Prof. Dr. Mehmet Balcılar
Chair, Department of Economics

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Doctor of Philosophy in Economics.

Prof. Dr. Mustafa Besim
Co-Supervisor

Assoc. Prof. Dr. Kamil Sertoğlu
Supervisor

Examining Committee

1. Prof. Dr. Mehmet Balcılar
2. Prof. Dr. Adalet Hazar
3. Prof. Dr. Mustafa İsmihan
4. Prof. Dr. İlhan Öztürk
5. Assoc. Prof. Dr. Kamil Sertoğlu

ABSTRACT

The thesis is structured into three parts. The first part measures the comparative advantage of crude oil in 28 oil-producing countries over the period 1990-2016 using the Normalized Revealed Comparative Advantage (NRCA) index. This part also explores the determinants of the comparative advantage including five explanatory variables with the use of second generation panel data techniques. The empirical result of the NRCA index revealed that not all the 28 sampled oil-producing countries have a comparative advantage in producing crude oil as shown in Appendix (B). The empirical evidence, from the cointegration test, demonstrated a long-run cointegrating relationship among the investigated variables. Further, the Panel ARDL model revealed that in the long run, all the investigated explanatory variables are vital determinants of the comparative advantage of crude oil. Specifically, crude oil price, daily average of crude oil production and institutional quality all contribute significantly in increasing the comparative advantage of crude oil, while domestic demand for crude oil and proven reserve decrease this comparative advantage. The negative effect of the proven reserve seems to align with the philosophy of scarcity rent. In the short run, the effects of the price of crude oil and daily average of crude oil production remain the same. However, proven reserve, domestic demand for crude oil and institutional quality all have insignificant effect. The Granger causality results detected a feedback effect between all the variables.

The second part of the thesis examines the relationship between environmental performance, comparative advantage of crude oil and institutional quality in 28 oil-producing countries over 13 years using two-step dynamic system GMM method.

The GMM estimations demonstrated that the environmental performance and institutional quality along with the conventional factors for comparative advantage are key determinants of the comparative advantage of crude oil. In particular, while environmental performance negatively affects the comparative advantage of crude oil, it is also negatively associated with the comparative advantage of crude oil. These results are in support of the pollution haven hypothesis in resource-based industry. Such results show a bidirectional relationship between environmental performance and comparative advantage of producing crude oil. Further, the results revealed a vital role played by institutional quality in enhancing the comparative advantage of crude oil and environmental performance. More so, the environmental Kuznets curve (EKC) hypothesis is validated in our result. Finally, a substantial difference in the results between OPEC and non-OPEC countries is confirmed by a set of dummy variables.

Finally, the third part inspects the differences of the effects of crude oil price, proven reserve of crude oil and daily production of crude oil on the comparative advantage of crude oil in a sample of 10 OPEC countries and 10 non-OPEC countries. the empirical result in the two panels also showed that crude oil price, daily average of crude oil production, and proven reserve have the same effects as found in the second and the third parts of this thesis. run. Regarding the direction of causality flow, bidirectional Granger causality is established between all the investigated variables in both panels.

Keywords: Comparative advantage; Crude oil production; Environmental Performance; Institutional Quality; OPEC countries; non-OPEC countries; NRCA index; Panel ARDL model; System GMM method.

ÖZ

Tez üç bölümden oluşmaktadır. İlk bölüm, 1990-2016 döneminde 28 petrol üreten ülkede Normalize Açıklanmış Karşılaştırmalı Avantaj (NRCA) endeksini kullanarak ham petrolün karşılaştırmalı üstünlüğünü ölçmektedir. NRCA endeksinin ampirik sonucuna göre, örneklenen 28 petrol üreten ülkenin tamamının ham petrol üretiminde karşılaştırmalı bir üstünlüğü olmadığı ortaya konmuştur Ek (B). Panel ARDL modeli, uzun vadede, araştırılan tüm açıklayıcı değişkenlerin ham petrolün karşılaştırmalı üstünlüğünün önemli belirleyicileri olduğunu ortaya koymuştur. Spesifik olarak, ham petrol fiyatı, günlük ortalama ham petrol üretimi ve kurumsal kalite, ham petrolün karşılaştırmalı üstünlüğünü artırmada önemli ölçüde katkıda bulunurken, ham petrol ve kanıtlanmış rezerv için yurt içi talep bu karşılaştırmalı üstünlüğü azaltmaktadır. Kanıtlanmış rezervin olumsuz etkisi kıtlık rantı felsefesi ile tutarlı görünmektedir. Kısa vadede, ham petrol fiyatının ve günlük ortalama ham petrol üretiminin etkileri kanıtlanmış rezerv, ham petrol için iç talep ve önemsiz bir etkiye sahip kurumsal kalite ile aynı kalmaktadır. Granger nedensellik sonuçları tüm değişkenler arasında bir geri besleme etkisinin olduğunu göstermektedir.

Tezin ikinci bölümünde, iki aşamalı dinamik bir sistem olan GMM yöntemi kullanılarak, 12 yıl boyunca 28 petrol üreten ülkede çevresel performans, ham petrolün karşılaştırmalı üstünlüğü ve kurumsal kalite arasındaki ilişki incelenmiştir. GMM tahminleri, çevresel performans ve kurumsal kalitenin, karşılaştırmalı üstünlük için konvansiyonel faktörlerle birlikte, ham petrolün karşılaştırmalı üstünlüğünün kilit belirleyicileri olduğunu göstermiştir. Özellikle, çevresel performans ham petrolün karşılaştırmalı üstünlüğünü olumsuz etkilerken, aynı

zamanda ham petrolün karşılaştırmalı üstünlüğü ile de negatif olarak ilişkili bulmuştur. Bu sonuçlar, kaynak temelli sektördeki kirliliğin hipotezini desteklemektedir ve çevresel performans ile ham petrol üretmenin karşılaştırmalı üstünlüğü arasında çift yönlü bir ilişki olduğunu göstermektedir. Ayrıca, sonuçlar ham petrol ve çevresel performansın karşılaştırmalı üstünlüğünün arttırılmasında kurumsal kalitenin oynadığı önemli bir rol olduğunu ortaya koymaktadır. Dahası, çevresel Kuznets eğrisi (EKC) hipotezi sonucumuzda doğrulanmıştır. Son olarak, OPEC ile OPEC üyesi olmayan ülkeler arasındaki sonuçlarda meydana gelen önemli bir fark, bir takım kukla değişkenlerle doğrulanmaktadır.

Son olarak, üçüncü kısım, 10 OPEC ülkesi ve 10 OPEC üyesi olmayan bir örneklemde, ham petrol fiyatının, kanıtlanmış ham petrol rezervi ve günlük ham petrol üretiminin ham petrolün karşılaştırmalı üstünlüğü üzerindeki etkilerini incelemekle devam etmektedir. Uzun dönem eş bütünleşme ilişkisini teyit etmenin yanı sıra, iki paneldeki ampirik sonuç aynı zamanda ham petrol fiyatının, günlük ortalama ham petrol üretimi ve kanıtlanmış rezervin bu tezin ikinci ve üçüncü bölümlerinde de aynı etkiye sahip olduğunu doğrulamış bulunmaktadır.

Anahtar Kelimeler: Ham petrol üretimi; Karşılaştırmalı üstünlük; Çevresel performans; Kurumsal Kalite; OPEC ülkeleri; OPEC üyesi olmayan ülkeler; NRCA indeksi; Panel ARDL modeli; Sistem GMM yöntemi.

DEDICATION

For the sake of Allah almighty, I dedicate this work to knowledge seekers

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

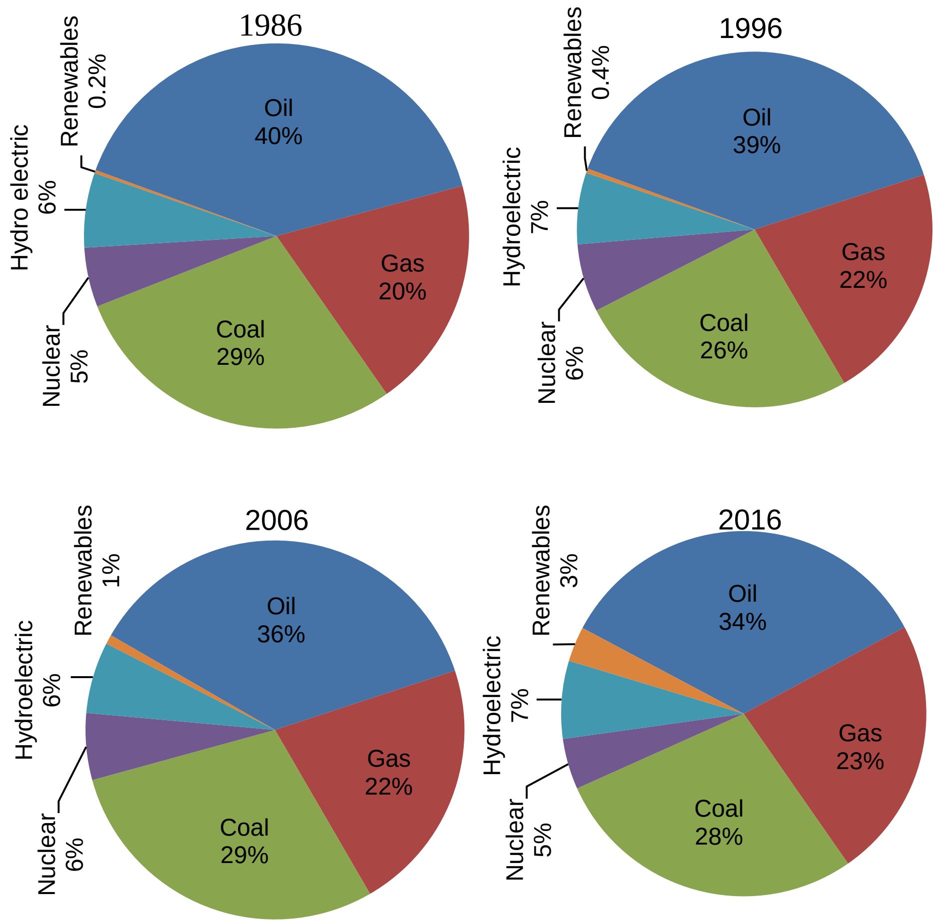
Chapter 1

INTRODUCTION

With the increasing wave of globalization and competitiveness, the global economy has become more competitive and borderless in the face of international movements of goods, services, and financial and human capital. Thus, the debate about comparative advantage, competitive advantage and competitiveness cannot be taken away from concept and theories of the international trade. Hence, based on the classical and neo-classical thoughts of international trade, the reason underpinning the international trade flows between countries is the diversity in comparative advantage. Therefore, during a significant period of time, the difference in comparative advantage between countries was attributed to factors abundance and advanced technologies. However, more recently, research interest has focused more attention on other factors such as innovation, economic scale, institutions, and environmental performance, particularly when some classical factors are identical (Belloc, 2006). Hence, it was difficult to apply such framework in an empirical analysis to measure the comparative advantage (Sanidas and Shin, 2010), until the time when Bella Balassa (1965) proposed the first and the most widely used Revealed Comparative Advantage (RCA) index (henceforth called BRCA), arguing that the comparative advantage is "revealed" in trade pattern since the trade pattern (structure of exports) reflects the differences in costs of production and non-price factors in specific country (Balassa, 1965). Since then there have been many attempts to revise and modify the BRCA index whether to overcome its shortcomings or to propose an alternative RCA index. In this regard, Yu, et al. (2009) proposed a Normalized Revealed Comparative Advantage index (NRCA) to overcome the shortcomings of the other RCA indices and to provide a reliable systematic tool for assessing the comparative advantage over a space and time.

The petroleum industry is a key resource-based industry and one of the massive-capital and advance-technology investment industry, consists of many activities such as exploration, production, refining and manufacturing as well as marketing. The backbone of this industry is the production of crude oil, which is a veritable, non-renewable, highly demanded and one of the most internationally traded commodities, produced in around 100 countries (EIA, 2017) and utilized all over the world as source of energy or an intermediate commodity. Therefore, rather than some political and strategic reasons, the competition is raged on in the global oil market between oil producers. While most of the crude oil-producing countries strategically aim at maximizing revenues from producing and exporting crude oil, others strategically aim at securing steady energy supplies. Figure (1) shows that, despite the decline in the share of crude oil in the world's energy consumption, the crude oil consumption is the highest with 40% in 1986. This decreases to 39 % in 1996, 36% in 2006 and 34% in 2016.

In the light of the aforementioned regarding the global competition, international trade and petroleum industry, this dissertation sets to answer investigative questions as to whether all the oil-producing countries have a comparative advantage in crude oil, and how different is the effect of the conventional and unconventional determinants of the comparative advantage on crude oil to other commodities. Therefore, this dissertation aims at conducting a comprehensive empirical work to assess the comparative advantage of crude oil production and to investigate the factors that determine the comparative advantage. The work is divided into the following three strands:



Source: Author's construction based on the data of BP Statistical Review of World Energy (2018)

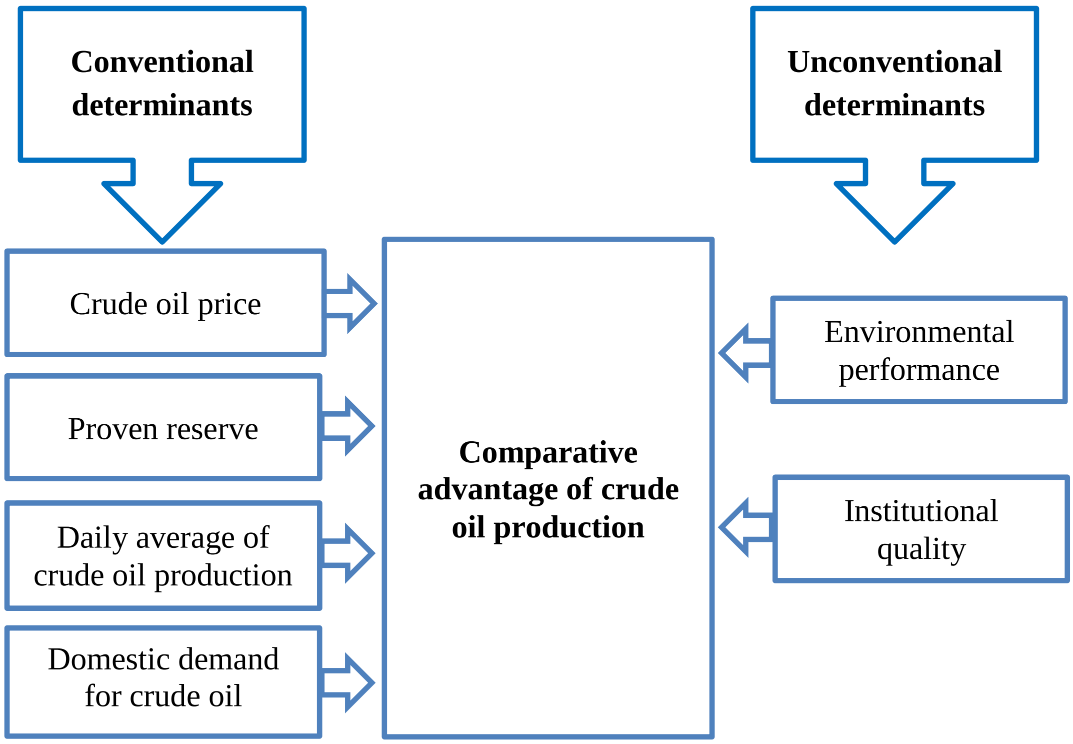
Figure 1: World Energy Consumption by Fuel

The first section of this dissertation aims at computing the comparative advantage of crude oil production in 28 oil-producing countries over the period of 27 years (1990 – 2016) and investigating the determinants of this comparative advantage.

The second section investigates the nexus between the comparative advantage of crude oil, environmental performance and institutional quality.

Finally, the third section studies the differences in the effect of the determinants of the comparative advantage of crude oil production in OPEC and non-OPEC countries.

Furthermore, the determinants of comparative advantage investigated in this dissertation were selected based on the empirical literature of comparative advantage. These determinants can be sorted into conventional and unconventional determinants as shown in Figure 2, relevant to the international trade theories of David Ricardo and Heckscher-Ohlin as well as some new research interesting such as environment and institutions.



Source: Author's construction

Figure 2: The Investigated Determinants of the Comparative Advantage of Crude Oil

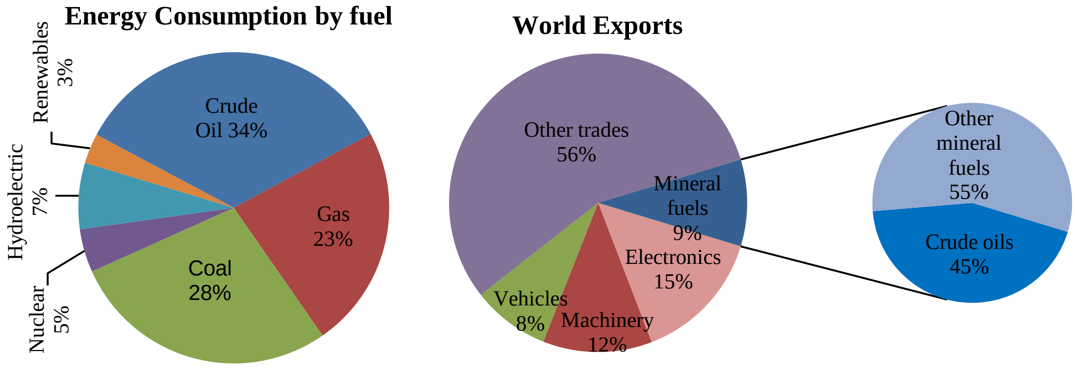
The first group is the conventional determinants of comparative advantage which are relevant to classical and neoclassical international trade theories consist of crude oil price to capture the exogenous shock of crude oil price and world demand for crude oil; proven reserve is the endowed nature resource of crude oil; domestic demand for crude oil for the endogenous effect of domestic demand for crude oil; daily average of crude oil production captures the production capacity and the technology level used in crude oil production. The second group includes the unconventional determinants which are environmental performance and institutional quality to capture the effects and the role of institutions and environmental policy on the comparative advantage of crude oil.

Chapter 2

COMPARATIVE ADVANTAGE OF CRUDE OIL PRODUCTION: EVIDENCE FROM 28 OIL PRODUCING COUNTRIES

2.1 Introduction

After the first global energy crisis in 1970s, a significant strategy has been implemented on the oil demand and supply to reduce the dependency on oil such as developing renewable alternative energy, controlling intensity and efficient use of energy, enhancing financial market power and control oil price (Hosseini and Shakouri 2016). However, oil still remains one of the most commonly used energy sources, highly demanded and one of the most internationally traded commodities. Figure 3 depicts that; crude oil is the most consumed source of energy with 34% of the total world's energy consumption, occupied 45% of the world's exports of mineral fuels in 2016.



Source: Author's construction based on data from BP Statistical Review (2018) and International Trade Center.

Figure 3: World Energy Consumption & World Exports in 2016

In the context of international trade theories and the condition of differences in comparative advantage for underpinning international trade between countries, basically, a country is said to have a comparative advantage in specific commodity (for instance crude oil) when it has an ability to produce this commodity at lower opportunity cost than other countries (Krugman and Obstfeld 2008). According to the classical thoughts, the comparative advantage diversity is linked to different levels of technologies and production factors abundance, while Heckscher and Ohlin linked the diversity of comparative advantage to the differences in relative factor endowments. However, more recently, research interesting has focused more attention towards other factors such as innovation, economic scale and institutions, particularly when some classical factors are identical (Belloc 2006). Essentially, in this context and in recognizing the importance of crude oil, this study sets to answer an investigative question as to whether all the oil-producing countries have a comparative advantage in crude oil, and how different is the effect of the drivers of the comparative advantage on crude oil to the effect on other commodities. Therefore, the objectives of this study are to gauge the comparative advantage of 28 oil-producing countries in crude oil production (see Appendix B) over the period of 27 years (1990-2016), and to evaluate the drivers of the comparative advantage in crude oil production of the aforementioned countries. This sample of countries is selected from the top oil producing countries based on their significant contribution in the world oil market.

Hence, the contribution of this study is to extend the literature of the comparative advantage to crude oil. In other words, we have observed that there is no empirical research has attempted to measure the comparative advantage in crude oil production and its determinants in such group of countries. More so, on the methodological issue, this study employs Panel ARDL model to estimate the short-run and long-run parameters and the direction of the relationship between the comparative advantage and each of the explanatory variables, in addition to incorporate the effect of institutional quality. These variables are selected to capture the effects of the exogenous shock of oil price, the endowed nature resource of crude oil and the endogenous effect of domestic demand and supply of crude oil as classical factors that drive the comparative advantage, as well as the effect of institutional quality as unconventional factor of the comparative advantage.

The remaining of this paper is organized as follows: Section 2 contains the literature review. Section 3 presents the methodology and data. Section 4 discusses the results and section 5 concludes the paper and puts down some policy implications.

2.2 Literature Review

Several empirical studies have investigated the comparative advantage of various economic activities using different indices[1] of Revealed Comparative Advantage (RCA) with numerous econometric techniques to identify the key drivers of comparative advantage.

For agricultural and food agricultural, Erokhin and Gao (2018) used the BRCA and the RTA indices to assess the Chinese agricultural production. The result found that agricultural production in China is apparently labour intensive not land intensive products. Similarly, Fertö and Hubbard (2003) analysed the Hungarian Agri-Food sector to conclude that indices are less satisfactory as they can only identify whether

1. The common indices of RCA in literature are: logarithm form of BRCA through RTA as a difference between lnRXA and lnRMA (Vollrath, 1987:1989); symmetrical RCA (RSCA) index (Dalum et al, 1998); weighted RCA index (WRCA) (Proudman and Redding, 2000); additive form of BRCA index (ARCA) (Hoen and Oosterhaven, 2006), Normalized Revealed Comparative Advantage (NRCA) (Yu et al. (2009).

a country has a comparative advantage or not. Bojnec (2001) using the RTA index found that import protection policies and export subsidies are major determinants of the comparative advantage of Central and East European Agricultural Trade. More so, using the NRCA index, Hoang et al. (2017) found natural-resource intensity to be a fundamental determinant of agricultural competitiveness in Vietnam. Sarker and Ratnasena (2014) found significant effect of labour cost and exchange rate on the comparative advantage of wheat, beef, and pork sectors in Canada. Also Seleka and Kebakile (2017) found that the growth in domestic demand for beef significantly affect comparative advantage of beef industry in Botswana. In addition, Balogh and Jambor (2017) investigated the sources of the comparative advantage of cheese production in the EU 27. The results showed that, GDP per capita, geographical factors and EU membership positively affect comparative advantage in cheese production. Conversely, FDI negatively affects the comparative advantage of cheese production. Moreover, Sharma et al (2014) investigated the competitiveness of Soymeal production in India compare to the competitors including Argentina, Brazil, China, Germany, Netherlands and Paraguay. The study submits that trade liberalization and demand growth of soymeal hampers comparative advantage in soymeal production in India.

For services and tourism sector, Algieri et al. (2018) employed the BRCA index to find that factor-intensity variables are significant determinants of comparative advantage in tourism services in the EU-28. Nath et al. (2015) exploring RSCA index for 16 services, established that the relative abundance of labour, human capital, and FDI inflows are significant sources of comparative advantage for the USA over China and India. More so, Toit et al. (2010) identifies factors responsible for comparative advantage in tourism sector for 146 countries. The study disclosed that transport, regional tourism indicators and natural environment positively affect competitiveness of tourism sector. Considering a case of 50 African countries (Fourie 2009), revealed that the sources of the comparative advantage in travel service vary with respect to natural and cultural resources. In addition, the result of the air transports concurs with the Heckscher-Ohlin hypothesis while sea transport does not. Seyoum (2007) analysed the comparative advantage of business, financial, transport and travel services in developing countries using the BRCA and the RTA indices. The results displayed that infrastructure and technological capability need to improve in these countries to enhance their competitiveness in services. More so, Langhammer (2004) assessed the comparative advantage of the USA, EU, and Japan in six selective services based on the RTA index. The result showed that the comparative advantage of the USA is superior to the other two trading partners. Telecoms innovations, high-income services market, productivity and FDI in services are the key factors influencing the comparative advantage of the USA in services.

For the textile and clothing sector, Chi and Kilduff (2006) analysed the comparative advantage of China in this sector through the BRCA approach. The result revealed that the textile sector in China is labour-intensive products; it is still away from being technically intensive products. However, the comparative advantage of the textile and clothing sector in Australia is attributed to the high quality and well-designed textile and clothing (Havrila and Gunawardana 2003).

Moreover, Ceglowski (2017) observed that computation of NRCA index with Value Added data provide different outcomes to the results obtained from the data of gross export. Ahrend (2006) assessed the comparative advantage of Russian industrial sectors through the RTA index. It was found that labour productivity was the source of the comparative advantage in advanced industrial sectors, while it remains limited in primary sectors such in hydrocarbons and energy-intensive commodities. Yeats (1985) investigated the comparative advantage of 40 manufacturing industries in 47 developed and developing countries on the basis of the BRCA index. His study found that the assumption of factor proportion theory plays a vital role in the comparative advantage of the industrial sector; in addition, government policy measures and resource endowments could be very helpful in formulating trade structure.

Regarding the role of institutions in the diversity of comparative advantage, Nunn and Trefler (2014) provide a comprehensive literature review to conclude that:

> institutional sources of comparative advantage can and do operate through fundamentally different channels than do traditional factors of comparative advantage such as endowments. Institutions are statistically and economically significant determinants of comparative advantage even after controlling for factor endowments. Indeed, there is abundant evidence that institutions are quantitatively as important as these traditional sources. (Nunn and Trefler 2014, pp.264)

On the side of the oil production literature, several studies documented that oil production responds to exogenous shocks in oil price, world oil demand and supply, global GDP, and endowments. However, oil-producing countries are differently responding to exogenous shocks in world oil demand and oil prices (Ratti and Vespignani 2015; Cologni and Manera 2014; Güntner 2014; Cashin et al. 2014; Hamilton 2008).

In light of the literature reviewed mainly from three different strands of literature, concerning the assessment and investigation of the determinants of comparative advantage, institutions as a source of comparative advantage and the factors affect crude oil production. We conduct this empirical study to measure the comparative advantage of producing crude oil and investigate the factors that determine this advantage.

2.3 Methodology and Data

In this study, the Normalized Revealed Comparative Advantage (NRCA) index proposed by Yu *et al*. (2009) is used to quantitatively measure the comparative advantage of crude oil production in each of the sampled countries. In addition, principle component analysis is employed to construct an indicator for institutional quality (IQ) from four components of institutional quality for each country. To this end, we employ a panel-data technique through Panel-Autoregressive Distributed Lag (P-ARDL) proposed by Pesaran et al. (1999) for estimating the nexus between the comparative advantage of crude oil measured by NRCA index and five explanatory variables, which include crude oil price (COP), proven reserve (PR), daily average of crude oil production (DAP), domestic demand for crude oil (DDO), and institutional quality (IQ). Thus, based on the extant literature reviewed we anticipate COP, PR, DAP and IQ to have a positive influence on the comparative advantage of crude oil, while DDO negatively affects this advantage as shown in Table 1.

In terms of data, this paper mainly depends on secondary data collected from the United Nation Com trade database to calculate the NRCA index; the Annual Statistic Bulletin of Organization of the Petroleum Exporting Countries (OPEC) for COP, PR, DAP and DDO; and PRS group data for institutional quality components.

Table 1: List of Variables

Variable	Notation	Measure	Expected Impact
Comparative advantage of crude oil	NRCA	Index	
Crude oil price	COP	US dollar	+
Proven reserve	PR	1000 of barrels	+
Daily average of crude oil production	DAP	1000 of barrels/day	+
Domestic demand for crude oil	DDO	1000 of barrels/day	-
Institutional quality	IQ	Index	+

2.3.1 Measurement of Comparative Advantages

The relatively new NRCA index is developed to remedy the defects of previous indices of comparative advantage. It provides reliable measure for the spatial and temporal evaluation of comparative advantage (Yu *et al*. 2009). Therefore this index possesses some favourable properties that make it a superior and the best in overcoming other flaws of the previous RCA indices (see Appendix A) (Liu and Gao 2019; Bebek 2017; Sanidas and Shin, 2010). Additionally, the NRCA index has a constant mean, symmetry, and distribution between -0.25 and + 0.25 which are required properties for time-series econometric analysis. Thus, the comparative advantage of a country *i* in commodity *j* can be calculated using the NRCA index as follow:

$$\mathrm{NRCA}_j^i = \frac{\Delta E_j^i}{E_w} = \frac{E_j^i}{E_w} - \frac{E_{wj} . E^i}{E_w . E_w} \quad (1)$$

Where; E_j^i denotes country *i*'s export of commodity *j* (crude oil). E^i denotes country *i*'s total export. E_{wj} denotes the world export of commodity *j* (crude oil) and E_w represents the world total export. NRCA measures the extent of variation of E_j^i (actual) from $\hat{E}_j^i$ (Natural level of comparative advantage) in relation to the world exports of commodity *j* under consideration. The natural level of the comparative advantage $\widehat{E}_j^i$ of E_j^i specifies as $\widehat{E}_j^i = \frac{E^i.E_j}{E}$. Therefore, when NRCA >0, the country has a comparative advantage in producing and exporting the commodity *j* (crude oil). Contrarily, the country has no a comparative advantage in producing and exporting commodity *j* when NRCA <0. That is, the country's export from the commodity (E_j^i) runs short of natural level of its comparative advantage ($\widehat{E}_j^i$) (Yu et al. 2009).

2.3.2 Institutional Quality Indicator

As mentioned, the principal component analysis is employed to derive a single indicator for institutional quality (IQ). The advantage of using this method is its technique to identify a conservative pattern in the data used to reduce number of dimensions of the data without losing significant information from the considered data (Joseph Francois 2007). Hence, following the empirical literature of institutional quality, the IQ variable is constructed by aggregating four main components of institutional quality from International Country Risk Guide (ICRG) of the PRS Group dataset (Ali *et al*. 2019; Jiang and Borojo 2018; Jong 2009; Busse and Hefeker 2007). The first component is government stability, which measures the ability of a government to carry out its declared policy and programs; Second component is corruption which evaluates the political corruption that threats foreign investment; Third component is democratic accountability, which reflects the responsiveness of the government to its citizens, fundamental civil liberties and political rights; Fourth component is bureaucracy quality, which stands for institutional strength and quality of the bureaucracy that absorbers or reduces shocks of policy revisions when governments change. Appendix (B) presents the eigenvalue and the proportion of aggregating the four components of institutional quality for each country in one indicator.

2.3.3 Panel Estimation

Following the empirical literature of the comparative advantage where the RCA indices employ within an econometric model to identify the key determinant of the comparative advantage. We employ P-ARDL approach to explore the association between comparative advantage and the explanatory variables earlier mentioned, where all the variables are expressed in natural logarithms except NRCA and IQ which have negative values. Additionally, we run robustness test through estimate the relationship between the variables by Pool OLS, Fixed Effect and Random Effect GLS Regressions with Driscoll-Kraay (1998) standard errors. This standard error assumes that the panel is heteroskedastic, autocorrelated, cross-sectional correlated, and it does not place any restrictions on the number of cross sections (N) or on the time variance (T) (Driscoll and Kraay 1998).

2.3.3.1 Test of Cross-Sectional Dependency

It is imperative to address two main issues for the choice of the strand (second-generation or first-generation) of panel data techniques to follow (Breitung and Pesaran 2008). Cross-sectional dependence (CD) is one of the issues. Since ignoring CD could results inefficient estimates of the panel data techniques and misleading conclusions therefrom. This is because the First-Generation panel data techniques were developed on the basis of the assumption of cross-sectional independency. Thus, this study employs Breusch and Pagan (1980) test by Lagrange multiplier (LM) statistics, Pesaran (2004) CD test and Pesaran, Ullah and Yamagata (2008) test. The tests are mathematically expressed as in the following equations:

$$CD_{LM} = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}^2{}_{ij} \qquad (2)$$

$$CD_{Pesaran} = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \right) \qquad (3)$$

$$CD_{LMad} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \frac{\hat{\rho}^2{}_{ij} - \mu_{Tij}}{v_{tij}} \tag{4}$$

From equation (2) T represents the time period where T = 1, 2,…,T; N is the number of cross sections; $i = 1,2,\ldots,N-1$ $j = i+1,2,\ldots,N$ and $\hat{\rho}_{ij}^2$ denotes squared correlation coefficients of residuals for *i* of coefficients of Pesaran (2004) CD test (Pesaran 2004). In equation (4) the specification of the bias adjustment test where k denotes the exogenous regressor; μ_{ij} denotes the mean and v_{ij} denotes the variance of $(T-k)\hat{\rho}_{ij}^2$ (Pesaran et al. 2008).

2.3.3.2 Test of Homogeneity

Homogeneity of the slope coefficients is the second issue which needs to be address in panel data technique. For diagnosing slope homogeneity, Swamy (1970) test is employed with the null hypothesis of slope homogeneity. The equation (5) is the specification of this test, where $\hat{S}$ has asymptotic χ^2 distribution, $\hat{\beta}$ is the slope parameters; x_i captures vector explanatory variables; $\hat{\beta}_{WFE}$denotes weighted fixed effect; $\hat{\sigma}_i^2$ stands for estimated σ_i^2 on the basis of $\hat{\beta}_{FE}$ and $X_i' M_\tau X_i$ is MG estimator (Swamy 1970).

$$\hat{S} = \sum_{i-1}^{N} \left(\hat{\beta} - \hat{\beta}_{WFE}\right)' \frac{X_i' M_\tau X_i}{\sigma^2{}_i} \left(\hat{\beta} - \hat{\beta}_{WFE}\right) \tag{5}$$

2.3.3.3 Panel Unit Root Test

Unit root test is a crucial task need to be done with suitable test concerns the existence of CD and heterogeneity in the panel, in order to ensure reliable results for the stationarity and the integration properties of the panel, for that reason, Pesaran (2007) unit root test for heterogeneous panel was employed. The test combines the conventional augmented dickey Filler test with the use of cross sectional averages of the series at levels and first difference. The null hypothesis is that the series is homogenous non-stationary.

$$CIPS\,(N,T) = N^{-1}\sum_{i=1}^{N} t_i\,(N,T) = \frac{\sum_{i=1}^{N} CADF_i}{N} \tag{6}$$

Where CADF denotes ADF statistic of N the number of cross sections, and T is time dimension $\mathrm{t} = 1, 2 \ldots \ldots \ldots .., \mathrm{T}$ (Pesaran 2007).

2.3.3.4 Panel Cointegration Test (Error Correction Approach)

The study used Westerlind (2008) panel cointegration test to examine long-run relationship between the variables. The test is the most desirable for panel data in the presence of heterogeneity, non-stationary, cross-sectional dependence and mixed order of integration (Westerlind 2008). This makes the test superior over other panel cointegration test. The null hypothesis of this test is “No cointegration”. The test is developed to test the null hypothesis when $\phi_i = 1$ in group and panel at the same time through two subtests as specified below:

$$DH_g = \sum_{i=1}^{n} \hat{S}_i\,(\breve{\emptyset}_i - \widehat{\emptyset}_i)^2 \sum_{t=2}^{T} \hat{e}_{it-1}^2 \tag{7}$$

$$DH_p = \hat{S}_i(\breve{\emptyset}_i - \widehat{\emptyset}_i)^2 \sum_{i=1}^{n} \sum_{t=2}^{T} \hat{e}_{it-1}^2 \tag{8}$$

DH_g and DH_p represent group mean and panel statistics respectively while $\widehat{\emptyset}_i$ is the ordinary least square (OLS) estimate of $\emptyset_i$ and $\mathrm{i} = 1, 2, \ldots \ldots \ldots \ldots \ldots .., \mathrm{n}$. $\hat{S}_i$ and $\hat{S}$ denote the variance ratios while $\breve{\phi}_i$ *and* $\breve{\phi}$ estimated via instrumentation of the residual $\hat{\mathrm{e}}_{\mathrm{it}}$ with $\hat{\mathrm{e}}_{\mathrm{it}-1}$. In the case of the DH_g, the null hypothesis of the test cannot be rejected when $\phi_i = 1$. Whereas, if $\phi_i < 1$ in at least one of the cross sections then the null hypothesis could rejected. For the DH_p the null hypothesis of the test cannot be rejected when $\phi_i = 1$ against the alternative hypothesis that $\breve{\phi}_i = \emptyset$ *and* $\breve{\phi}_i < 1$ for all cross sections (Westerlund 2008).

2.3.3.5 Granger Causality Test

To explore the causality relationship between the investigated variables in the panel, we employ causality test developed by Emirmahmutoglu and Kose (2011). This test follows Granger causality process of Meta analysis to check for causality relationship in heterogeneous and mixed order of cointegration panel. The test follows Toda Yamamoto (1995) technique to test for coefficient restrictions in VAR system. Emirmahmutoglu and Kose (2011) test is an ideal to employ in case of non-stationary and non-cointegrated time series and it is able to check for the causality relationship in panel data with cross-sectional dependency through the bootstrap procedure (Emirmahmutoglu and Kose, 2011). The specification of the test considers the regression of VAR model in heterogeneous panel as follows:

$$x_{i,t} = \mu_i^x + \sum_{j=1}^{k_i+d\,max_i} A_{11,ij}\, x_{i,t-j} + \sum_{j=1}^{k_i+d\,max_i} A_{12,ij}\, y_{i,t-j} + u_{i,t}^x \qquad (9)$$

$$y_{i,t} = \mu_i^y + \sum_{j=1}^{k_i+d\,max_i} A_{21.ij}\, x_{i,t-j} + \sum_{j=1}^{k_i+d\,max_i} A_{22,ij}\; y_{i,t-j} + u_{i,t}^y \qquad (10)$$

Where equation (11) checks for causality running from *y* to *x* and equation (12) checks the causality running from *x* to *y*; *t* and *i* denote to time variance and cross sections respectively; *k* is max lag; *d max i* is maximal order of integration that may occur in each *I*; A is constant matrices of parameters varies across each *i*.

2.3.3.6 Panel Estimation Model

Panel Autoregressive Distributed Lag (P-ARDL) model for large T and N panel is employed in this study to inspect the effect of independent variables on the calculated comparative advantage. The model has desirable properties that made it popularly used model. It accounts for endogeneity, mixed order of integrated series (I(1) and I(0)) and gives short-run and long-run parameter estimates separately. In addition, the P-ARDL is an intermediate procedure which serves as improvement on Pooled Mean Group, Mean Group and Dynamic Fixed Effect models. (Pesaran *et al.*1999). The model is expressed as follows:

$$y_{it} = \sum_{j=1}^{p} \gamma_{ij}\, y_{i,t-j} + \sum_{j=0}^{q} \sigma_{ij}'\, x_{i,t-j} + \mu_i + \epsilon_{it} \qquad (11)$$

y_{it} and x_{it} represent the dependent variable and independent variable for group i at time t respectively. Time period, t = 1, 2, ….,T and number of groups, i = 1, 2, …..,N; σ_{ij} and γ_{ij} are the coefficients of the independent variables and the lagged dependent variable respectively. On the basis of equation (9), the empirical model of this study is specified as follows:

$$\mathrm{NRCA}_{it} = \sum_{j=1}^{\rho} \gamma_{ij} y_{i,t-j} + \sum_{j=1}^{\rho} \sigma_{ij} \mathrm{lnCOP}_{i,t-j} + \sum_{j=1}^{\rho} \sigma_{ij} \mathrm{lnPR}_{i,t-j} + \sum_{j=1}^{\rho} \sigma_{ij} \mathrm{lnDAP}_{i,t-j} + \sum_{j=1}^{\rho} \sigma_{ij} \mathrm{lnDDO}_{i,t-j} + \sum_{j=1}^{\rho} \sigma_{ij} \mathrm{IQ}_{i,t-j} + \mu_i + \epsilon_{it} \quad (12)$$

2.4 Empirical Results and Discussion

2.4.1 Measuring NRCA in Crude Oil

Based on the calculated scores of the NRCA index of the comparative advantage of crude oil in the sampled countries reported in Appendix (B), we can conclude that not all the sampled 28 oil-producing countries have a comparative advantage in producing crude oil. While Algeria, Angola, Azerbaijan, Colombia, Ecuador, Gabon, Iran, Iraq, Kazakhstan, Kuwait, Libya, Mexico, Nigeria, Norway, Oman, Qatar, Russia, Saudi, UAE and Venezuela have a comparative advantage in crude oil, on the other hand, Brazil, China, the UK and USA do not have a comparative advantage in crude oil. Whereas the comparative advantage of Canada, Egypt, Indonesia and Malaysia is revealed just for specific years during the study period as shown in the Appendix (B). Nonetheless, discussing these results in light of the Heckscher Ohlin (H-O) trade theory implies that, as oil production is a capital-intensive industry (Westney 2011), our results, therefore, are in support of the H-O theory in case of capital-abundant countries like Algeria, Canada, Iran, Iraq, Kazakhstan, Kuwait, Libya, Nigeria, Norway, Oman, Qatar, Russia, Saudi, UAE (Bolbol and Young 1992). However, for Brazil, the UK and USA as capital-abundant countries (Muriel and Terra 2009; Krugman 2008) the results do not support this theory.

Thus, In other words, countries that have no a comparative advantage in crude oil such as Brazil, China and the USA the opportunity cost of exporting oil in the these countries seem to be much higher than using the produced crude oil domestically. Particularly, these countries are industry based countries which may choose to use the produced crude oil in other industries rather than exporting. However, countries such as OPEC countries and other similar economies where the industry is not that developed, they do not need as much crude oil to use domestically.

From another perspective, Appendix (B) provides statistical compression for the NRCA, PR, production and consumption of crude oil for each country in the sample. It is clear that all the countries that enjoy a comparative advantage in crude oil have an increased PR with crude oil production greater than the consumption. However, in case of Brazil, China and the USA it can be seen that although the PR improved during the period of the study, the crude oil consumption is much higher than production of crude oil throughout the period of the study. With respect to the UK and Malaysia although the crude oil production is higher than the consumption with diminished PR throughout the period of the study, the UK has no comparative advantage and Malaysia lost its comparative advantage 1994 to 2016. Although in Canada the PR is augmented with crude oil production greater than the consumption, its comparative advantage did not revealed from 1990 to 2005 then revealed up to 2016. Further, Indonesia lost its comparative advantage from 2008 – 2016 with decreased PR and crude oil consumption greater than the production. Egypt also lost its comparative advantage between 2004 and 2010 then it is marginally revealed with increased PR and crude oil production slightly higher than the consumption.

2.4.2 Empirical Results of Panel Estimation

Beginning with test for the cross-sectional dependence, where the result in Table 2 obviously confirm that the panel data is plagued by cross-sectional dependence since the null hypothesis of the independence cross sectional is rejected at 1% level of significance based on the LM and LM bias adjustment tests, and it is rejected at level of 5% based on Pesaran (2004) CD test.

Table 2: Results from Cross-Sectional Dependence Test

	Constant		Trend	
Test	Statistic	p-value	Statistic	p-value
LM	761.7	0.000	805.4	0.000
LM adj*	28.23	0.000	29.34	0.000
LM CD*	1.853	0.063	2.067	0.038

Source: Authors' computations
*Two-sided test

Regarding the homogeneity of the slope coefficients, the result of Swamy (1970) test in Table 3 indicates for heterogenic slope parameters, where the null hypothesis of homogenous slope is rejected at significance level of 1%. The table also reports the results for the heteroskedasticity and autocorrelation tests. Thus, based on the results of the diagnostic tests we can conclude that following second Generation panel methods ensures efficient and robust estimates.

Table 3: Results from Homogeneity, Heteroskedasticity and Autocorrelation Test

	Test	Statistics	Probability
Homogeneity	Swamy (1970)	chi2(162) = 6820.3	Prob > chi2 = 0.000
Heteroskedasticity	Breusch-Pagan/ Cook-Weisberg	chi2(1) = 11.41	Prob > chi2 = 0.007
Autocorrelation	Wooldridge	F(1, 27) = 172.782	Prob > F = 0.000

Source: Authors' computations

Further, the result of the unit root test presented in Table 4, indicated for a different order of variables cointegration, where the lnCOP and lnPR variables are stationary at a level I(0) and all NRCA, lnDAP, lnDDO and IQ variables are stationary at first difference I(1).

Table 4: Results from CIPS test of Unit Root

	Level		1st difference	
	Constant	Constant & trend	Constant	Constant & trend
NRCA	-2.343	-2.177	-4.270***	-4.314***
lnCOP	-3.242***	-3.420***	-5.651***	-5.770***
lnPR	-2.261**	-2.794**	-4.676***	-4.675***
lnDAP	-2.041	-2.197	-4.015 ***	-4.028***
lnDDO	-2.046	-1.996	-4.308***	-4.536***
IQ	-2.057	-2.356	-4.380***	-4.536***

Source: Authors' computations
Notes: ***, ** and * denote 0.01, 0.05, and 0.10 significance levels

Regarding the long-run relationship, the results of Westerlund (2008) cointegration test reports evidence to reject the null hypothesis of no cointegration both in the panel and in groups at 5% level of significance when the test is carried out with a constant and with a constant and trend as appears in Table 5. These results, therefore, confirm the existence of the relationship in the long-run between the investigated variables.

Table 5: Result from Westerlund (2008) Panel Cointegration Test

	Non		Constant		Constant & trend	
	Statistic	P-value	Statistic	P-value	Statistic	P-value
DHg	-1.528	0.063	-2.072	0.019	-2.136	0.016
DHp	-0.412	0.340	-1.559	0.059	-2.196	0.014

Source: Authors' computations

The causality test results shown in Table 6 present a bidirectional causality relationship between the NRCA variable and the five independent variables. This confirms the existence of the relationship between the investigated variables detected by the cointegration test. Finally, based on these results of the cointegration and the causality tests we employ P-ARDL to estimate the coefficient of the proposed relationship in model (12).

Table 6: Result of Emirmahmutoglu and Kose Granger Causality Test

Independent variable	Dependent variable	Statistic	P-Value
COP	NRCA	86.42	0.006
NRCA	COP	71.70	0.077
PR	NRCA	88.080	0.004
NRCA	PR	76.49	0.036
DAP	NRCA	89.55	0.000
NRCA	DAP	79.99	0.000
DDO	NRCA	85.37	0.000
NRCA	DDO	81.32	0.000
IQ	NRCA	86.58	0.005
NRCA	IQ	72.16	0.072

Source: Authors' computations

The results of the P-ARDL (1, 1, 1, 1, 1) via PMG, MG and DFE methods are contained in Table 7. However, due to the presence of heterogeneity in the panel we just consider the PMG and MG estimations. While the DFE estimation is presented just to provide a complete P-ARDL model. Consequently, Hausman test is applied for comparison between the MG and PMG. Hence, the null hypothesis of homogeneity restrictions cannot be rejected (chi2(5) = 3.32; Prob>chi2 0.650), meaning that the PMG estimation is preferable to the MG estimation.

The results of the MG and PMG methods indicate that the speed of adjustment coefficient is negative and statistically significant at 1% for the PMG and the MG estimates. This confirms the relationship between the variables in the long run indicated by Westerlund (2008) Panel Cointegration test reported in Table 5.

Regarding the coefficients of COP in Table 7, the estimation of the PMG shows that the coefficient of COP is positive both in long run ($\sigma_1 = 1.13, p < 0.01$) and short run ($\sigma_1 = 1.01, p < 0.01$) and statistically significant at 1%. This indicates that COP has positive effect on the comparative advantage in this group of countries.

Table 7: PMG, MG and DFE Estimations & Hausman Test Results

	PMG	MG	DFE
Speed of adjustment coefficients	-0.207***	-0.506***	-0.232***
	(0.031)	(0.055)	(0.024)
Long-run coefficients			
L.lnCOP	1.131***	3.191**	0.454***
	(0.081)	(1.536)	(0.149)
L.lnPR	-0.584***	-5.344	0.103
	(0.200)	(2.131)	(0.265)
L.lnDAP	1.479***	2.332	1.416***
	(0.192)	(1.739)	(0.316)
L.lnDDO	-0.709***	-7.081**	-0.359
	(0.193)	(3.039)	(0.281)
L.IQ	0.299***	0.220	0.893
	(0.057)	(0.406)	(0.946)
Short-run coefficients			
D.lnCOP	1.013***	1.104***	0.943***
	(0.256)	(0.262)	(0.072)
D.lnPR	-1.282	-0.368	0.541
	(2.347)	(1.010)	(0.865)
D.lnDAP	1.955***	2.153***	1.331***
	(0.469)	(0.439)	(0.128)
D.lnDDO	-0.243	-0.811	-0.474*
	(0.406)	(0.688)	(0.248)
D.IQ	0.0121	0.226	0.538
	(0.333)	(0.463)	(0.836)
Constant	-2.150***	4.252	-2.535***
	(0.331)	(5.281)	(0.043)
Hausman test	MG vs PMG		
chi2(5)	3.32		
Prob>chi2	0.650		

Source: Authors' computations
Notes: ***, ** and * denote 0.01, 0.05, and 0.10 significance levels

The result implies that an increase in COP brings about an increase in the NRCA via an increase in production and exportation of crude oil. However, according to Cologni and Manera (2014) oil producing countries are characterized by different responses to exogenous shocks in world oil demand and oil prices. Conventionally, such relationships are always investigated in form of comparison between the reactions of OPEC and non-OPEC countries. Therefore, our result supports the positive relationship between the COP and crude oil production in OPEC countries based on the findings of Ratti and Vespignani (2015); Brémond *et al*. (2012); Kaufmann *et al*. (2004). In addition, this finding is congenial to Ramcharran (2002) who found a positive relationship between COP and crude oil production in non-OPEC countries. Conversely, this result is not consistent with a negative association between COP and crude oil production found by Ramcharran (2002) in the both groups of countries documented by Ratti and Vespignani (2015).

The result further indicates a significant negative relationship between PR and NRCA in the long-run ($\sigma_2 = -0.58, p < 0.01$) and a negative but insignificant relationship in the short run ($\sigma_2 = -1.28, p < 0.65$). This result conforms to the concept of Hotelling rent or scarcity rent (Krautkraemer 1998; Hamilton 2008) which posits that the price of exhaustible resource inclines to exceed its marginal cost or to be in the level of the market interest rate to compensate the depletion of the resources. Since oil is non-renewable resource (Frankel 2010) the inverse relationship between PR and NRCA could be attributed to that growth in PR results in abundance of crude oil supply which in turn negatively affects the crude oil price. This result agrees with the submission of Yeats (1985) which observed that natural resource have fundamental relationship with comparative advantage. However, this result contrast the positive relationship between natural resource and comparative advantage in other economic sectors documented by Heller (1976), Gunton (2003), Svaleryd and Vlachos (2005), Fourie (2009), Toit *et al*. (2010), Hoang *et al*. (2017) and Balogh and Jambor (2018).

The DAP is positively related to NRCA and statistically significant in both the short-run ($\sigma_3 = 1.195, p < 0.01$) and long-run ($\sigma_3 = 1.47, p < 0.01$). These results align with the finding of Yue and Hua (2002) which concludes that growth in domestic production propels exports.

Moreover, the DDO has a negative and highly significant impact on the comparative advantage of crude oil in the long run ($\sigma_4 = -0.70, p < 0.01$) and negative but not significant in the short run ($\sigma_4 = -0.24, p < 0.406$). These results are in support of the idea documented by Bowen (1983) that the comparative advantage is a net trade concept (Vollrath 1991). This negative influence of domestic demand on comparative advantage has also being proved by Seleka and Kebakile (2017) and Sharma *et al.*, (2014). The implication of this relationship can be traceable to the fact that increase in home demand leads to upward pressure on local production. This may also lead to import crude oil in some cases to cover the increasing domestic demand. This result could be clearly seen in the case of the world biggest oil consumers – the USA and China. Although these countries are among the top10 oil producers, they have no comparative advantage in producing crude oil. Based on statistics reported in Appendix (B), for instance in 2016, crude oil production in the USA and China is 12365.8 and 3999.2 thousand barrels respectively and their consumption is 19687.2 and 12301.7 thousand barrels.

Lastly, the IQ variable positively affects the comparative advantage of crude oil in the long run at 1% level of significance ($\sigma_5 = 0.29, p < 0.01$). This result implies that the IQ is a fundamental determinant of the comparative advantage of crude oil along with classical factors. Our result, therefore, is consistent with the result found by Francois and Manchin (2013) and Nunn and Trefler (2014) that institutional quality is a source of comparative advantage. The result is also found congenial to the significant positive relationship of institutional quality, international trade and export performance documented by Francois and Manchin (2013).

Furthermore, the results of the robustness of the P-ARDL through Pooled OLS, Fixed Effect and Random Effect GLS Regressions reported in Table 8 confirmed the results of the P-ARDL. This suggests that our findings are robust.

Table 8: Pooled OLS, Fixed Effect and Random Effect Results

	Pooled OLS	RE GLS	FE (within)
lnCOP	0.481***	0.481***	0.427***
	(0.046)	(0.046)	(0.053)
lnPR	-0.138*	-0.138***	-0.167*
	(0.034)	(0.348)	(0.093)
lnDAP	0.535***	0.535***	1.44***
	(0.071)	(0.071)	(0.110)
lnDDO	-0.186**	-0.186***	-0.495**
	(0.030)	(0.030)	(0.098)
IQ	3.128***	-3.128***	10.57***
	(0.307)	(0.307)	(0.883)
Constant	0.035	0.035	0.031
	(0.033)	(0.033)	(0.032)

Source: Authors' computations

2.5 Conclusion and Policy Implications

This study investigated the comparative advantage of crude oil production and their drivers in 28 oil-producing countries. At the beginning, the NRCA index was computed for the sampled countries over the period of 27 years (1990–2016). The results of the NRCA index revealed that not all sampled countries seemingly have a comparative advantage in producing crude oil. In addition, the scores of the comparative advantage vary across the countries. Particularly, countries like Algeria, Angola, Azerbaijan, Colombia, Ecuador, Gabon, Iran, Iraq, Kazakhstan, Kuwait, Libya, Mexico, Nigeria, Norway, Oman, Qatar, Russia, Saudi, UAE and Venezuela were found to have a comparative advantage in producing crude oil, while countries like Brazil, China, the UK and the USA had no comparative advantage in producing crude oil. With respect to Canada, Egypt, Indonesia and Malaysia, their comparative advantage was only revealed for specific years during the study period. The results of Algeria, Canada, Iran, Iraq, Kazakhstan, Kuwait, Libya, Nigeria, Norway, Oman, Qatar, Russia, Saudi, UAE, therefore, leaned support to the Heckscher Ohlin (H-O) theory while the results of Brazil, the UK and the USA failed to lean support to this theory. To investigate the determinants of the comparative advantage in crude oil, a P-ARDL model has been employed. The econometric outcomes showed that the conventional and unconventional factors that drive international trade and trade specialization are important drivers of comparative advantage in crude oil. Therefore, these results support the assumptions of the international trade theories. In details, the five explanatory variables in our model which are COP, PR, DAP, DDO and IQ contribute significantly to comparative advantage diversity in the long term, with the effect of COP, DAP and IQ being positive and the effect of DDP and PR being negative. Whereas, in the short term the COP and DAP have similar effects found in the long term but the effect of PR, DDP and IQ was insignificant statistically. The plausible theoretical explanation for the negative effect of PR on the comparative advantage of crude oil is linked with the notion of scarcity rent advocated by Harold Hotelling (1931) where the price of exhaustible resource inclines to exceed its marginal cost or to be in the level of the market interest rate to compensate the depletion of the natural resources, even in a perfectly competitive market. To this extend, if all the countries have endowed crude oil, then the supply abundance decreases oil price which in turn leads to decrease production and exportation. This consequentially results to an inverse relationship between the PR and comparative advantage. However, this result was contrary to the positive relationship between the endowed natural resources and the comparative advantage established by the majority of other empirical studies for other commodities. More so, the robustness tests using the pooled OLS, Fixed effect, and Random effect estimators confirmed the results. Furthermore, concerning the direction of the relationships between the variables, a feedback effect of Granger causality was established between all the investigated variables.

These results highlight a significant insight for policymakers since it imparts a basic understanding for the comparative advantage of such essential commodity (crude oil). Also the results provide empirical evidence about which country has, and which has no a comparative advantage in crude oil, in addition to identifying the factors that drive the comparative advantage diversity in crude oil. This would be clear for policymakers to target a specific factor to enhance this advantage in the countries that have no comparative advantage in crude oil, or to sustainable this advantage in the countries that have a this advantage. Further, our findings brought an attention for the role of one of the unconventional determinants of comparative advantage which is institutional quality, where it is important to focuses on the role of the conventional factors along with the unconventional factors such as institutions, environmental performance in order to enhance and sustainable the comparative advantage in this essential production.

Chapter 3

ENVIRONMENTAL PERFORMANCE, COMPARATIVE ADVANTAGE OF CRUDE OIL AND THE ROLE OF INSTITUTIONAL QUALITY

3.1 Introduction

The petroleum industry is a key resource-based industry involving many activities such as exploration, production, refining and manufacturing. The backbone of this industry is the production of crude oil, which is non-renewable, highly demanded, one of the most internationally traded commodities, causing 31% of the total CO2 emissions and 11% of CH4 over the world in 2017 (Olivier and Peters, 2018)

The classical and neoclassical international trade theories[2] postulate that a country could obtain a comparative advantage in a specific commodity (for instance crude oil) when it has an able to produce the specific commodity by lower opportunity cost comparing to other countries (Krugman, 2008). Hence, comparative advantage is the responsible factor underpinning international trade flows across countries over the world. Therefore, over a number of years, the diversity of comparative advantage has been empirically investigated using some conventional determinants such as technological differences and relative factor endowments. More recently, research

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2. The classical international trade theory is comparative advantage theory of David Ricardo and the neoclassical trade theory is the Heckscher-Ohlin theory.

interest has focused more on other factors such as institutions, innovation, economic scale and environmental performance.

At the beginning of the global awareness of the environmental problems between 1960s and 1970s, specific attention focused on the link between environmental policy and international trade (Van Beers and Jeroen Bergh, 1996). This relationship extensively studied in the literature to confirm the hypothesis of pollution haven. This hypothesis argues that high environmental performance has negative influence on the comparative advantage of a country when a stringent environmental policy applies on the production of a specific commodity. Consequently, strict environmental policy reduces the exports of this commodity and increases its imports to substitute local production. More importantly, although no international trade theory has considered the effects of institutional differences on the comparative advantage yet, institutions have received a great deal of research interest in recent years to investigate its implication on comparative advantage and environmental performance (Levchenko, 2007). Such research reveals the effective role of institutional quality in enhancing comparative advantage and environmental performance.

In this context, there are important investigative questions to be asked such as whether a relationship exists between environmental performance and the comparative advantage of crude oil as a resource-based industry. Do institutional quality and environmental performance have an influence on the comparative advantage of crude oil along with the conventional determinants of comparative advantage? And does the institutional quality exert upward or downward pressure on environmental performance and the comparative advantage of crude oil?

Thus, the objectives of this study are to investigate the relationship of the comparative advantage of crude oil with environmental performance and institutional quality along with the conventional determinants of comparative advantage, and to investigate the effect of the comparative advantage of crude oil on environmental performance by incorporating the role of institutional quality in a sample of 28 oil-producing countries for the period 2002-2014. We further investigate the existence of the environmental Kuznets curve (EKC) hypothesis for this group of countries along with the comparative advantage of crude oil and institutional quality. Moreover, following the empirical literature on crude oil in compression with regard to the behaviours of OPEC and non-OPEC oil-producing countries, we used a set of dummy variables to investigate the differences in these relationships in the OPEC and non-OPEC countries.

This study contributes to the literature by investigating the effects of environmental performance and institutional quality on the comparative advantage of crude oil. It goes beyond the investigation of the effect of the comparative advantage of crude oil on environmental performance by incorporating the role of institutional quality. In other words, to the best of our knowledge no previous empirical study has considered the comparative advantage of crude oil by employing the approach of revealed comparative advantage (RCA), and combining the conventional and unconventional determinants of comparative advantage.

3.2 Literature Review

As is well known, the main conceptualisation of comparative advantage goes back to David Ricardo (1817) who argued that the reason behind international trade flows between countries is comparative advantage which is triggered by differences in opportunity costs, i.e. differences in production functions and technology level (Algieri et al., 2018). However, Heckscher and Ohlin (H-O) submitted that if the production function and the level of technology are identical, then comparative advantages can result from relative differences in factor endowments. Thus, the majority of empirical studies on comparative advantage aim to assess comparative advantage and investigate the factors affecting it in the context of a variety of goods and services.

In the existing literature on agricultural and food agricultural Bojnec (2001) Fertö and Hubbard (2003), Abidin and Loke (2008), Sarker and Ratnasena (2014), Sharma et al. (2014), Ndayitwayeko et al. (2014), Hoang et al. (2017), Seleka and Kebakile (2017), Balogh and Jambor (2017) and Erokhin and Gao (2018) have argued that natural resources, import protection policies, export subsidies, exchange rate, GDP per capita, geographical factors, growth in domestic demand, labour cost and FDI inflows all are key determinants of comparative advantage in agricultural and food agricultural. Langhammer (2004), Seyoum, (2007) and Nath et al. (2015) concluded that relative abundance of labour, FDI inflows, innovations, productivity and infrastructure are found to be significant sources of comparative advantage in services. Further, in the tourism sector, Fourie (2009), Toit et al. (2010) and Algieri et al. (2018) found factor intensity, transport, regional tourism and natural and cultural resources to be significant determinants of comparative advantage. In textiles and clothing, Chi and Kilduff (2006) and Havrila and Gunawardana (2003) found that labour abundance, high quality and well-designed textiles to be significant factors driving comparative advantage. Moreover, in the industrial sector, Yeats (1985), Valentine and Krasnik (2000), Utkulu and Seymen (2004) and Ahrend (2006) concluded that labour productivity, factor intensity, government policy measures and resource endowments are the key factors driving comparative advantage.

The growing literature on the topic of comparative advantage and environmental performance has suggested different results. Results have validated the pollution haven hypothesis in Mexico (Low, 1992), North-South trade flows (Cole, 2004), the cross-section of 71 developed and developing countries (Quiroga et al. 2009), and the USA (Broner et al. 2012); meanwhile, others have found insignificant influence of environmental performance on comparative advantage in the USA, in bilateral trade between US and Mexico (Tobey, 1990; Grossman and Krueger, 1993), in developed countries (Albrecht, 1998; Chua, 2003), in India (Dietzenbacher and Mukhopadhyay, 2007), in developing economies (Beladi and Chao, 2006) and in the bilateral trade between 14 EU countries and China (Marconi, 2012). Further, Van Beers and Jeroen Bergh (1997) argued that environmental policy has a significant negative impact on comparative advantage for non-resource-based industry and insignificant negative impact on comparative advantage in for resource-based industry. Kearsley and Riddel (2010) also found a different result in a sample of 27 developed OECD countries, where the pollution haven hypothesis was validated in the case of 2-digit SIC and rejected in the case of 3-digit SIC. This conflict in the results is attributed to different general conditions in cases study, poor data and the relatively low compliance cost of environmental policy (Chua, 2003) as well as the differences in levels of environmental policy (Copeland and Taylor, 1997), i.e. the environmental policy dominates the trade pattern only when it has a sufficiently large impact, otherwise the effect of factor abundance will revealed the comparative advantage.

Regarding the influence of institutional quality on comparative advantage, there is almost consensus in the literature that institutions positively and significantly impact comparative advantage (Levchenko, 2007; Costinot, 2009; Francois and Manchin, 2013; Nunn and Trefler, 2014). Furthermore, a growing literature also can be found emphasising the significance of institutional quality in enhancing environmental performance (Ibrahim and Law, 2016; Mavragani et al., 2016; Ali et al. 2019).

Thus, based on the literature relating to comparative advantage, environmental performance and institutional quality which has been reviewed, no such comprehensive empirical study has been carried out on the comparative advantage of crude oil. Therefore, we conduct this empirical study to explore the relationship of the comparative advantage of crude oil with environmental performance and institutional quality.

3.3 Methodology and Data

We use the Normalized Revealed Comparative Advantage (NRCA) index to quantitatively measure the comparative advantage of crude oil in the sampled countries, as a starting point. This index was proposed to overcome the shortcomings of the previous RCA indices and to provide a reliable systematic tool for assessing comparative advantage over space and time with suitable properties for econometrics and time series analysis (Yu et al., 2009). Then we employ principal component analysis to derive a single indicator for institutional quality by aggregating four components of institutional quality from the International Country Risk Guide (ICRG) dataset. The selected components are Government Stability, Corruption, Democratic Accountability, and Bureaucracy Quality. The main advantage of using principal component analysis is its ability to identify a conservative pattern for the given data to reduce the number of dimensions of the data without losing too much information (Francois and Manchin, 2007). To this end, a system-GMM method proposed by Arellano and Bond (1995) and Blundell and Bond (1998) is implemented to estimate the relationship between the investigated variables in the three models below. In general, modeling of panel data has been accompanied with the problems of endogeneity and heteroskedasticity. Therefore, the system-GMM with a lagged dependent variable as the endogenous variable was proposed to address these problems. Further, this method provides and grantees robust results particularly in the case of our panel when the number of countries exceeds the number of periods (Arellano and Bond, 1995; Blundell and Bond, 1998). The two-step dynamic SYS-GMM estimator is expressed as:

$$NRCA_t = \alpha_0 + \alpha_1 NRCA_{it-1} + \alpha_2 EPI_{it} + \alpha_3 IQ_{it} + \alpha_4 lnCOP_{it} + \alpha_5 lnPRI_{it} + \alpha_6 lnDDO_{it} + \alpha_7 lnPR_{it} + \alpha_8 D_{OPECit} + \epsilon_{it1} \quad (13)$$

$$EPI = \beta_0 + \beta_1 EPI_{it-1} + \beta_2 NRCA_{it} + \beta_3 IQ_{it} + \beta_4 lnGDP_{it}^2 + \beta_5 lnGPD_{it} + \beta_6 D_{OPEC} + \epsilon_{it2} \quad (14)$$

$$lnCO2 = \theta_0 + \theta_1 lnCO2_{it-1} + \theta_2 NRCA_{it} + \theta_3 IQ_{it} + \theta_4 lnGDP_{it}^2 + \theta_5 lnGPD_{it} + \beta_6 D_{OPEC} + \epsilon_{it3} \quad (15)$$

Where α_0, β_0, and θ_0 donates to the constants, *i* represents the i^{th} series and *t* represents the period of time period (2002 - 2014). NRCA is the comparative advantage of crude oil; EPI is the environmental performance index; IQ is an indicator of institutional quality; COP is the daily average of crude oil production; PRI is the price of crude oil price; DDO is the domestic demand for crude oil; PR is the proven reserve; GDP is the gross domestic product in millions of constant 2010 US dollars; DOPEC is a dummy variable for OPEC countries. All the investigated variables are expressed in the logarithm forms except NRCA; EPI and IQ variables, which are in original values due to negative values. Moreover, these variables are selected to characterise two groups of the determinants of comparative advantage. The first group is conventional determinants of comparative advantage relevant to classical and neoclassical international trade theories such as PRI to capture the exogenous shock of oil price and world demand for crude oil; PR is the endowed nature resource of crude oil, DDO for the endogenous effect of domestic demand for crude oil, COP captures the production capacity and the technology level used. The second group includes unconventional determinants which are IQ and EPI for institutional quality and environmental performance respectively.

In terms of data, this study employs secondary data assembled from the UN Comtrade database for computing the NRCA index, data from the World Bank databases for GDP, as well as data from the OPEC Annual Statistic Bulletin database for COP, PRI, DDO and PR. Further, the data used for the components of the IQ are retrieved from the International Country Risk Guide (ICRG) dataset of PRS Group. The EPI is sourced from the database of the Yale Center for International Earth Science Information Network (CIESIN).

3.4 Empirical Results and Discussion

Theoretically, comparing the scores of the NRCA and the EPI indices in Appendix (D) we observe that some countries, such as Canada and Norway, with high environmental performance have a comparative advantage of crude oil, while others, such as the UK and USA, have no comparative advantage of crude oil. In contrast, some countries, such as Angola and Libya, with low environmental performance have a comparative advantage of crude oil. This result, therefore, partially supports the Pollution haven hypothesis.

Table 9: Two Steps System GMM Results

	(1) NRCA		(2) EPI		(3) $lnCO_2$	
	Coefficient	Std. Err	Coefficient	Std. Err	Coefficient	Std. Err
L.Dep-Ver[1]	0.664***	0.012	-0.381***	0.019	0.628***	0.0290
NRCA			-0.091***	0.009	0.172***	0.0393
EPI	-0.111***	0.021				
IQ	0.145***	0.024	0.575***	0.086	-0.042**	0.017
lnCOP	0.153***	0.015				
lnPRI	0.028**	0.011				
lnDDO	-0.065***	0.031				
lnPR	-0.307**	0.060				
$lnGDP^2$			-0.264**	0.124	-0.039**	0.017
lnGDP			5.508**	2.269	0.735**	0.308
D_{OPEC}	1.137***	0.159	-6.592***	1.883	-0.493**	0.224
Constant	2.905***	0.514	4.813***	0.831	-2.442*	1.432
AR(1), Z	-2.2628		-2.9403		-3.0391	
Prob > z	0.0236		0.0033		0.0024	
AR(2), Z	-0.45799		-0.5137		1.4188	
Prob > z	0.647		0.6075		0.156	
Sargan test						
chi2(73)	19.418		25.4765		17.5720	
Prob > chi2	0.9012		0.8365		0.9032	

Source: Authors' computations
1 Lagged-dependent variable.
Note ***, ** and * denote 1%, 5%, and 10% significance levels

Empirically, model (13) aims to investigate the determinants of the comparative advantage of crude oil by incorporating environmental performance and institutional quality as unconventional determinants with conventional determinants such as COP, PRI, PR and DDO. The results in Table 9 indicate a negative and significant effect of environmental performance on the comparative advantage of crude oil ($\alpha_2 = -0.111, p < 0.01$). The finding, therefore, supports the Pollution haven hypothesis in resource-based industry. This means that setting up a stringent environmental policy has a negative effect on the comparative advantage of crude oil. It also supports the existing studies such of Low (1992), Cole (2004), Quiroga et al. (2009) and Broner et al. (2012). However, the result is inconsistent with the findings documented by Van Beers and Jeroen Bergh (1997) for an insignificant negative impact of environmental policy on comparative advantage in resource-based industry.

Model (13) further shows a positive effect of institutional quality on the comparative advantage of crude oil ($\alpha_3 = 0.145, p < 0.01$). This result is similar to the positive impact of institutional quality on comparative advantage documented by Francois and Manchin Levchenko (2007), Costinot (2009), Francois and Manchin (2013) and Nunn and Trefler (2014).

The investigated classical determinants of comparative advantage in model (13) are found to be fundamental determinants of the comparative advantage of crude oil. Specifically, the COP and PRI positively stimulate the comparative advantage of crude oil ($\alpha_4 = 0.153, p < 0.01$) and ($\alpha_5 = 0.028, p < 0.05$). These results are consistent with the positive response of oil-producing countries to an increase in oil price that was documented by Ramcharran (2002) and Ratti and Vespignani (2015). Conversely, DDO has a negative and significant impact on comparative advantage of crude oil ($\alpha_6 = -0.065, p < 0.01$), substantiating the findings of Seleka and Kebakile (2017) who found a negative influence of local demand on comparative advantage. However, the established negative relationship between PR and the comparative advantage of crude oil ($\alpha_7 = -0.307, p < 0.05$) is incompatible with the positive effect of the natural resources on comparative advantage found by Hoang et al. (2017) and Balogh and Jambor (2018). This result is consistent with the idea of scarcity rent discussed by Harold Hotelling (1931) cited in Frankel (2010).

In model (14) a negative effect of the comparative advantage of crude oil on environmental performance is established ($\beta_2 = -0.091, p < 0.01$). This means that the comparative advantage of crude oil negatively affects environmental performance. Due to the lack of literature investigating the effect of comparative advantage on environmental performance, this relationship could be confirmed through the inverse relationship between environmental performance and CO_2 emissions submitted by Thomakos and Alexopoulos (2016) and Lee and Min (2015). Where our result shows a positive association is established in model (3) between the comparative advantage of crude oil and CO_2 emissions ($\theta_2 = 0.172, p < 0.01$). This result agrees with the findings of Kanemoto et al. (2014), Ling et al. (2015) and Fernández-Amador et al. (2016) who found a positive association between comparative advantage and CO_2 emissions. Therefore, this result implies that the comparative advantage of crude oil could weaken environmental performance by increasing CO_2 emissions.

Respecting institutional quality, the results show a positive and significant role for institutional quality in environmental performance ($\beta_3 = 0.575, p < 0.01$) in model (14) and negative and significant effect of institutional quality on CO_2 emissions ($\theta_3 = -0.042, p < 0.05$) in model (15). Our results suggest that efficient institutional quality improves environmental performance by reducing CO2 emissions. The results, therefore, concur with the results of Mavragani et al. (2016), Ibrahim and Law (2016) and Ali et al. (2019) who found a positive impact of institutional quality in enhancing environmental performance.

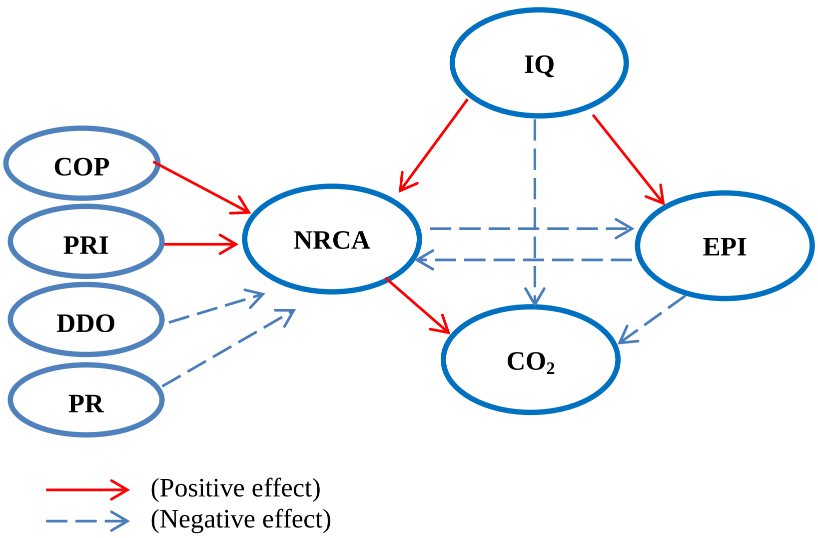
Furthermore, from the results of model (15), the association between economic growth which proxy by GDP and CO_2 emissions validates the hypothesis of Kuznets curve (EKC), whereby the CO_2 emissions are positively linked with GDP ($\theta_5 = 0.735, p < 0.05$) and negatively associated with the squared GDP ($\theta_4 =$

$-0.039, p < 0.05$). The result also indicates that economic growth stimulates environmental performance ($\beta_4 = 5.508, p < 0.05$).

Finally, the dummy variables (DOPEC) show a substantial difference in the results between the OPEC and non-OPEC countries in the sample. The OPEC dummy is positive and statistically significantly related to NRCA, while it is negatively related to EPI and CO2 emissions.

3.5 Conclusion and Policy Implications

This study aims to explore the relationships of the comparative advantage of crude oil with environmental performance and institutional quality using three indices – NRCA, EPI and IQ in 28 oil-producing countries during the period 2002-2014.



Source: Author's construction

Figure 4: Established Relationships between the Variables

Figure (4) presents a graphical abstract for the established relationships between the investigated variables in the three models employing the two-step Dynamic System-GMM technique. Thus, the results revealed that environmental performance and institutional quality are both key determinants of the comparative advantage of crude oil along with conventional determinants relative to classical and neoclassical international trade theories such as COP, PRI, DDO and PR. Thus, COP, PRI and institutional quality all contribute significantly to increasing the comparative advantage of crude oil, while environmental performance, DDO and PR decrease this comparative advantage. Hence, the established negative effect of environmental performance on the comparative advantage of crude oil validates the pollution haven hypothesis in resource-based industries.

Besides the negative impact of the environmental performance on the comparative advantage of crude oil, our result revealed negative influence of the comparative advantage of crude oil on environmental performance. These findings submit that the association between environmental policy and the comparative advantage of crude oil is bidirectional, i.e. environmental performance and comparative advantage of crude oil negatively affect each other. From another perspective, the result proved a positive relationship between the comparative advantage of crude oil and CO2 emissions. This result confirms the established negative impact of comparative advantage on environmental performance through the inverse relationship between environmental performance and CO2 emissions. This means that having a comparative advantage in producing crude oil increases CO2 emissions and weakens environmental performance.

The empirical findings further revealed a significant positive effect of institutional quality on the comparative advantage of crude oil and environmental performance as well as a negative effect on CO2 emissions. These results propose that higher quality of institutions enhances the comparative advantage of crude oil, improves environmental performance and reduces CO2 emissions.

Regarding economic growth and environmental degradation, our empirical results validate the environmental Kuznets curve (EKC) hypothesis in the presence of the influence of the comparative advantage of crude oil and institutional quality. Moreover, a significant difference is found between the OPEC and non-OPEC countries through the inclusion of dummy variables.

This study filled the existing gap in empirical analysis of the relationship between the comparative advantage of crude oil, environmental performance and institutional quality through the RCA approach and panel data econometrics. Our results successfully validate the pollution haven hypothesis in resource-based industries and a bidirectional negative relationship between environmental performance and comparative advantage of crude oil. Thus, further empirical analysis is needed to investigate the established relationship in the short and the long term besides investigating the causality relationships among the investigated variables. Additionally, further studies are needed on the basis of cross sections using time series analysis, particularly for those countries which have high environmental performance and which were found to have a comparative advantage in crude oil such as Canada and Norway.

The policy implications for our outcomes is that governments and environmental policymakers in the sampled countries should be aware of the disadvantage of having a comparative advantage in crude oil and the implications of high-quality institutions that are able to work towards reducing environmental degradation caused by comparative advantage in such industries. This should be supported by strengthening the quality of public and private institutions to proficiently implement and prioritise environmentally friendly production policies to balance between enhancing comparative advantage and improving environmental performance.

Chapter 4

DETERMINANTS OF THE COMPARATIVE ADVANTAGE OF CRUDE OIL PRODUCTION: EVIDENCE FROM OPEC AND NON-OPEC COUNTRIES

4.1 Introduction

Unquestionably, the main contribution of the classical and the neoclassical international trade theories is linking the flows of the goods and services between countries to the differences in comparative advantage. While David Ricardo postulated that the comparative advantage is a result of different level of technology used or productivity between the countries, Heckscher and Ohlin attributed the diversity of comparative advantage to the variances in relative factor endowments. Hence, the comparative advantage of crude oil as one of the most internationally traded commodities and the most consumed source of energy (Elsalih et al., 2019) may not be far away from the hypotheses of these theories due to the specifications of this commodity as a non-renewable and scarce source of energy produced in about 100 countries and utilized all over the world (EIA, 2017).

Hence, due to the imperious need for a applicable technique to measure the comparative advantage, Bella Balassa[3] in 1965 introduced the first and most widely-used index to evaluate the comparative advantage believing that the comparative advantage is “revealed” in the export structure, which is also known as the revealed method of the comparative advantage (RCA). In the literature of the comparative advantage, various empirical studies can be found employing a number of alternative RCA indices[4].

4.2 Literature review

Regarding the extant literature of employing the relatively new Normalized Revealed Comparative Advantage (NRCA) index, Hoang et al., (2017) investigated the Vietnam agriculture sector to reveal that natural resource intensity is a key source of the comparative advantage in this sector. For the EU 27, Stefan and Imre (2018) concluded that the level of economic development, the size of the country and EU membership all significantly affect the comparative advantage of the agri-food exports. On the basis of across commodity studies, Seleka and Kebakile (2017) submitted that growth in the domestic demand for beef has a negative effect on the comparative advantage of the beef industry in Botswana. For EU 27 cheese production (Balogh and Jambor, 2018) the empirical results showed that while GDP per capita, geographical (place of origin) indication and the EU membership have positive effects, FDI has a negative effect on this advantage. In the USA, Saki et al., (2019) found that cotton fiber; artificial filament tow, cotton yarn, carpet and other floor coverings are sources of the comparative advantage of textiles and apparel. Hoang and Tran (2019) demonstrated rice, coconut and pomelo crops are sensitive to

3. It is worth noting here that Balassa proposed his RCA index based on the idea of Liesner (1958) about using the Relative performance of export as an indicator of comparative advantage.
4. The most commonly used indices for RCA in the literature are Balassa index; logarithm form of Balassa index of net trade lnRTA; symmetrical RCA index; weighted RCA index; additive form of Balassa index and Normalized Revealed Comparative Advantage.

climate and market changes, while water charges and land tax have no impact on the comparative advantage of these crops in Vietnam. Furthermore, investigating the competitiveness of the Indian production of soymeal with its main competitors (USA, Brazil, Argentina, Paraguay, Germany, the Netherlands and China) (Sharma, et al., 2014), the findings showed that trade liberalization and the growth of local demand for soymeal negatively affect the competitiveness of Indian soymeal. More so, in an attempt to recognize the sources of the comparative advantage in the tourism sector in 146 countries (Toit, et al., 2010), the result disclosed that the natural environment, transport, and regional tourism variables have a positive and significant impact on the comparative advantage of tourism, where this result aligns with the Heckscher-Ohlin theory and to some extent with the Krugman theory. Likewise, in a study for travel service in 50 African countries from a sample of 147 countries (Fourie, 2009), the findings revealed that the sources of the comparative advantage in travel service vary in natural and cultural resources. Furthermore, air transport rather than sea transport concurs with the Heckscher-Ohlin hypothesis. In a different development, exploring the value-added data along with the gross exports data to compute the NRCA index for assessing the export competitiveness of 56 countries in three manufacturing and two service industries (Ceglowski, 2017), the results found that using value-added data may provide different outcomes compared to conventional gross exports data.

Based on the foregoing literature reviewed, it is clear that most of the empirical studies which assessed the comparative advantage using the NRCA index or other RCA indices did not consider the comparative advantage of crude oil. Therefore, the objective of this study is to measure the comparative advantage of producing crude oil, and to investigate the determinants of this advantage for a sample of 20 countries selected from the biggest crude oil producing countries, on the basis of 10 OPEC countries and 10 non-OPEC countries (see Appendix B) over a period of 27 years (1990-2016). This sample was selected due to the importance of these countries in the world's oil market and to capture the effect of different production policies between the two groups.

To the best of our knowledge, no comprehensive empirical study has been conducted for assessing the comparative advantage of crude oil production, particularly in such groups of countries. Therefore, the contribution of this study is to bridge this gap by calculating and comparing the comparative advantage of crude oil production in different production policies (OPEC and non-OPEC) using the relatively new the NRCA index for measuring the comparative advantage, and the heterogeneous panel autoregressive distributed lag (Panel ARDL) model, in order to identify the determinants of the comparative advantage of producing crude oil. In addition, this study explores a panel Granger causality test to determine the direction of the causal relationship between the comparative advantage and the three independent variables in two separate panels.

The rest of this paper is structured as follows: Section 2 presents the methodology and data descriptions, Section 3 presents the empirical results and finally, Section 4 concludes and lays out some policy implications.

4.3 Methodology and Data

The methodology of this paper simply calculates the comparative advantage of crude oil production for the sampled countries using the NRCA index, then employs a panel data technique using the Panel ARDL approach to estimate the association between the comparative advantage of crude oil and three explanatory variables, which are price of crude oil (COP), proven reserve (PR) and an average of daily crude oil production (ADP) for each group of countries in two separate panels. Moreover, for further examination of the relationship between the investigated variables we run robustness' test through the first generation approaches such Pooled OLS, Fixed Effects and Random Effects regressions with Driscoll-Kraay (1998) standard errors, where this standard error accounts for heteroskedastic, autocorrelated, cross sections correlation, and infinite number N and T panel (Driscoll and Kraay, 1998). In terms of data, annual frequency data was collected from the database of UN Comtrade to calculate the NRCA index, while other yearly data was gathered from the Annual Statistic Bulletin of OPEC for the three explanatory variables (COP, PR and ADP).

4.3.1 Measuring Revealed Comparative Advantages

This study employs the NRCA index proposed by Yu et al., (2009) to assess the comparative advantage of crude oil production due to its favorable properties in such empirical studies as a precise, consistent and systematic tool for assessing the comparative advantage over space and time (Yu et al., 2009). In this regard, many empirical studies have demonstrated a number of the preferable and superior properties of this index (see Bebek, 2017; Deb and Hauk, 2017; Deb and Basu, 2011; Sanidas and Shin, 2010) where the NRCA index is the most successful index that overcomes the shortcomings of other RCA indices, except the normality of error terms assumption. Hence, the NRCA for a country *i* in commodity *j* can be calculated as follows:

$$\mathrm{NRCA}_{\mathrm{j}}^{\mathrm{i}} = \frac{\Delta \mathrm{E}_{j}^{i}}{\mathrm{E}} = \frac{\mathrm{E}_{j}^{i}}{\mathrm{E}} - \frac{\mathrm{E}_{j}.\mathrm{E}^{i}}{\mathrm{E.E}} \qquad (16)$$

Where E_j^i refers to the exports of country *i* of commodity *j*; E^i is the total exports of the country *i*; E_j is the world's total exports of the commodity *j*; E is the world's total exports. The method of the NRCA index basically gauges the degree of deviation of actual E_j^i from the neutral point of its comparative advantage $\widehat{E}_j^i$ in respect of its relative scale comparing to the world's exports of the same commodity. The neutral point of the comparative advantage $\widehat{E}_j^i$ of E_j^i is expressed as $\widehat{E}_j^i = \frac{E^i.E_j}{E}$. Accordingly, it says that a country *i* enjoys a comparative advantage in the commodity *j* when $NRCA > 0$, this means that $E_j^i > \widehat{E}_j^i$; in other words, the exports of country *i* of commodity *j* is greater than the neutral point of its comparative advantage. Whereas, when $NRCA < 0$, it says that the comparative advantage of the country *i* non revealed in the commodity *j*, which means $E_j^i < \widehat{E}_j^i$, i.e. the exports of country *i* of the commodity is lower than its neutral point.

4.3.2 Cross-Sectional Dependency Test

In order to employ a panel data framework in such a study, we need to address two main issues to decide whether to follow first or second-generation panel estimations (Breitung and Pesaran, 2008). One of these issues is the cross-sectional dependency (CD), since ignoring CD could lead to serious consequences such as weakness of inferences and the results of the unit root tests. Therefore, in this study, three combined tests are used to investigate presence of CD in both panels under the null hypothesis of cross-sectional independence. The Breusch and Pagan (1980) test uses the Lagrange multiplier (LM) statistics, Pesaran (2004) CD test checks for CD in sufficiently large T and infant N panel with unit root and dynamic heterogeneity, and Pesaran, Ullah and Yamagata (2008) test uses bias adjustment LM statistics with zero mean to test for CD in infinite N and T panel. This test maintains a satisfactory power in a panel with exogenous regressors and normal errors. These tests are specified as follows:

$$CD_{LM} = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}^{2}_{ij} \quad (17)$$

$$CD_{P} = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \quad (18)$$

$$CD_{LMadj} = \sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\frac{(T-k)\hat{\rho}^{2}_{ij}-\mu_{Tij}}{v_{Tij}} \quad (19)$$

Equation (17) is the specification of the Breusch and Pagan(1980) test, where T is the time t = 1,2,...,T; N is cross-section dimension; i = 1,2,...,N-1; j = i+1,2,...,N; $\hat{\rho}^2_{ij}$ is the squared estimation of the pair-wise correlation of the residuals for every i (Breusch and Pagan, 1980). In Pesaran (2004) CD test (equation 18) $\hat{\rho}_{ij}$ is pair-wise correlation coefficients (Pesaran, 2004). In Bias adjusted LM test (equation 19), k is the exogenous regressor; μ_{Tij} and v_{Tij} are the mean and the variance of $(T-k)\hat{\rho}^2_{ij}$ (Pesaran *et.al*, 2008).

4.3.3 Homogeneity Test

The second main issue that needs to be addressed in the panel data framework is the homogeneity of the slope parameters. Therefore, the Swamy (1970) test is employed to detect whether the slope is homogeneous through examining the null hypothesis of slope homogeneity.

$$\hat{S} = \sum_{i=1}^{N}(\hat{\beta} - \hat{\beta}_{WFE})'\frac{X_i' M_\tau X_i}{\hat{\sigma}_i^2}(\hat{\beta} - \hat{\beta}_{WFE}) \quad (20)$$

Where $\hat{S}$ is asymptotical chi-square distribution; $\hat{\beta}$ is slope coefficients of regressors; x_i is vector regressors; $\hat{\beta}_{WFE}$ is weighted fixed effect; $\hat{\sigma}_i^2$ is an estimator of σ_i^2 based on $\hat{\beta}_{FE}$ and $X_i' M_\tau X_i$ is the mean group (MG) estimator (Swamy, 1970).

4.3.4 Unit Root Test

In order to explore the properties of stationarity and integrating level of the variables, Pesaran CIPS (2007) unit root test for heterogeneous panels is employed to check for the unit root in both panels. This test augments the typical Augmented Dickey-Fuller test (ADF) with averages of the cross sections and the first difference of each time series. This test examines the null hypothesis of homogeneous non-stationary.

$$\mathrm{CIPS(N,T)} = \mathrm{N}^{-1}\sum_{\mathrm{i=1}}^{\mathrm{N}} \mathrm{t_i(N,T)} = \frac{\sum_{\mathrm{i=1}}^{\mathrm{N}} \mathrm{CADF_i}}{\mathrm{N}} \quad (21)$$

Where N and T is the number of cross sections and the time period respectively, CADF is ADF statistic of the cross sections (Pesaran, 2007).

4.3.5 Panel Error Correction Cointegration Test

Westerlund (2008) developed the Durbin-Hausman panel cointegration test to examine the existence of the long run cointegration relationship in panel data under different conditions such as heterogeneity, cross-sectional dependency, the absence of stationarity and mixed order of cointegration. The test is designed with two subtests - $\mathrm{DH_g}$ test for group mean statistic and $\mathrm{DH_p}$ test for panel statistic.

$$\mathrm{DH_g} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \hat{S}_i(\breve{\phi}_i - \hat{\phi}_i)^2 \sum_{\mathrm{t=2}}^{\mathrm{T}} \hat{\mathrm{e}}_{\mathrm{it-1}}^2 \quad (22)$$

$$\mathrm{DH_p} = \hat{S}_n(\breve{\phi} - \hat{\phi})^2 \sum_{\mathrm{i=1}}^{\mathrm{n}} \sum_{\mathrm{t=2}}^{\mathrm{T}} \hat{\mathrm{e}}_{\mathrm{it-1}}^2 \quad (23)$$

Where $\hat{\phi}_i$ is the OLS estimator of ϕ_i; $\breve{\phi}_i$and $\breve{\phi}$ are calculated from instrumenting the residual $\hat{e}_{it}$ with its consistent estimation $\hat{e}_{it-1}$; $\hat{S}_i$ and $\hat{S}$ are variance ratios. The null hypothesis in both subtests is no cointegration when $\phi_i = 1$. Accordingly, in $\mathrm{DH_g}$ test the null hypothesis of no cointegration cannot be rejected when group statistics $\phi_i = 1$, while the alternative hypothesis of existing the cointegration accepted when $\phi_i < 1$ in at least one i, where $i = 1, \dots, n$. Whereas in $\mathrm{DH_p}$ test the null hypothesis cannot be rejected when panel statistic $\phi_i = 1$ against the alternative hypothesis of $\phi_i = \phi$ and $\phi_i < 1$ for all i (Westerlund, 2008).

4.3.6 Autoregressive Distributive Lag (ARDL) Panel Estimates

In order to estimate the second generation panel (heterogeneous and non-stationary panel), Pesaran, et al. (1999) introduced Panel autoregressive distributed lag (Panel ARDL) model for large T and N. This model is relatively new and widely used in econometrics researches, due to its enviable advantages to accounts for endogeneity, separately provides long-run and short-run coefficients and can be applied for mixed order integrated variables, i.e. whether I(0) or I(1) or partially integrated (Pesaran, et al. 1999). Specifically, the Panel ARDL as an advanced version of the ARDL model works via three different methods of Mean Group (MG), Pooled Mean Group (PMG) and Dynamic Fixed Effect (DFE). Thus, the Panel version of ARDL model is specified as in the following equation:

$$y_{it} = \sum_{j=1}^{p} \lambda_{ij}\, y_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij}\, x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{24}$$

Where t is the time period t = 1,2,...,T, i is the number of the group (cross sections) = 1,2,...,N; y_{it} is the dependent variable of the group i in time t; x_{it} is the independent variables of group i in time t; while the coefficient of the independent variables is δ_{ij}; λ_{ij} is the coefficient of the lagged dependent variable $y_{i,t-j}$. Thus, specifying this model based on equation (9) for the two panels yields:

$$NRCA_{it} = \sum_{j=1}^{p} \lambda_{ij} NRCA_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij}\, COP_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij}\, PR_{i,t-j} + \sum_{j=0}^{q} \delta'_{ij}\, ADP_{i,t-j} + \mu_i + \varepsilon_{it} \tag{25}$$

Technically, this model is an intermediate procedure model, where the PMG works between MG and DFE functions. Specifically, while the MG estimates both short-run and long-run coefficients allows for heterogeneity, the DFE restricts homogeneity in both short-run and long-run, PMG allows for heterogeneity in the short-run and restricts homogeneity in the long-run (Pesaran, et al. 1999).

4.3.7 Granger Causality Test

Dumitrescu and Hurlin in (2012) developed the panel Granger causality test based on the Granger (1969) test, to check for causality relationship running from an independent variable to a dependent variable in heterogeneous panels with T larger than N as specified in the following equation:

$$\mathcal{Y}_{i,t}=\alpha_i+\sum_{k=1}^{K}\gamma_i^{(k)}\mathcal{Y}_{i,t-k}+\sum_{k=1}^{K}\beta_i^{(k)}\chi_{i,t-k}+\varepsilon_{i,t} \qquad (26)$$

Where t is the time variance t = 1,2,…,T; i is individuals = (1,2,…,N); $\mathcal{Y}_{i,t}$ and $\mathcal{X}_{i,t}$ are dependent and independent variables respectively; α_i is the variable effect; assumed to be constant during the period; K is lag orders which are identical for all cross sections. This test allows autoregressive parameter through $\gamma_i^{(k)}$, and heterogeneous slope parameters through $\beta_i^{(k)}$. Further, the null hypothesis is homogeneous non-causality, which specified as:

$$H_0: \beta_i = 0 \quad \forall_i = 1, \ldots N$$

$$H_1: \beta_i = 0 \quad \forall_i = 1, \ldots N_1$$

$$\beta_i = 0 \quad \forall_i = N_1 + 1, N_1 + 2, \ldots, N$$

Where N_1 is the unknown coefficient that fulfills the condition $0 \leq \frac{N_1}{N} < 1$; the ratio of $\frac{N1}{N}$, must be less than one. Thus, If N_1 = N, it signifies non-Granger causality relation within the panel, while if $N_1 = 0$ means Granger causality relationship within the panel (Dumitrescu and Hurlin, 2012). Additionally, as the Dumitrescu and Hurlin in (2012) causality test requires the time series to be stationary at level, i.e. this test does not account for unit root; we differentiate the non-stationary variables based on the results of the unit root test.

4.4 Empirical Results and Discussion

4.4.1 Measuring the NRCA for producing Crude Oil and Empirical Results

Appendix (B) presents the estimated scores of the NRCA for the 10 OPEC countries. In general, all OPEC countries have a comparative advantage, with Saudi Arabia having the highest average score of the NRCA in the group. Iran, Venezuela, UAE, Nigeria and Kuwait are the second highest average scores, followed by Iraq, Algeria, Libya and Qatar as third.

On the other hand, from the estimated scores of the NRCA for the non-OPEC group of countries also presented in Appendix (B) clearly can be seen that five countries have a comparative advantage in crude oil production, with Russia having the highest average of NRCA values. This is followed by Norway, Kazakhstan, Oman and Mexico respectively. Interestingly, neither the USA nor China, who are the biggest oil consumers, has a comparative advantage in producing crude oil. For the UK and Brazil, neither had a comparative advantage during the period, with an exception in some years where their comparative advantage was marginally revealed. With regard to Canada, it had no comparative advantage in crude oil production from 1992 to 2005. Then, its comparative advantage came to light between 2006 and 2016.

However, in light of the Heckscher Ohlin (H-O) trade theory[5] and the nature of the oil production industry as a capital-intensive industry (Westney, 2011), our results for all OPEC countries, as capital-abundant countries (Bolbol and Young 1992), therefore support the H-O theory. In addition, the results show that Canada, Russia,

5. The Heckscher and Ohlin (H-O) trade theory states that a comparative advantage is the result of differences in relative endowments of the production factors. In a model of two countries producing two goods with two production factors (capital and labour), the capital-abundant country will enjoy a comparative advantage in producing and exporting the capital-intensive commodity, while the relative labour-abundant country will gain a comparative advantage in producing and exporting the labour-intensive commodity.

Norway and Kazakhstan as capital-abundant countries have a comparative advantage in crude oil production which is also congenial to this theory. However, the results that Brazil, the UK and the USA have no comparative advantage even though they are capital-abundant countries are supported by Muriel and Terra (2009) for Brazil, Krugman (2008) for USA, and Greenaway et al., (1994) for the UK.

4.4.2 Empirical Results of Panels Estimation

Table 10 presents the results of the three tests employed to check for the correlation between the cross sections of the panels. The results provide a strong evidence to reject the null hypothesis of cross-sectional independence at 1% level of significance in the OPEC panel. This means that all the cross-sectional errors are correlated in the panel (cross-sectional dependence). The same decision holds for the second panel based on CD_{LM} and Adjusted CD_{LM} tests. On the contrary, the CD_P test indicates cross-sectional independence in the non-OPEC panel. Therefore, it can be concluded generally that cross-sectional dependence is present in both panels. In other words, following the second generation panel model technique guarantees better and more robust results than the first generation panel model.

Table 10: Panel Cross-Sectional Dependence Tests

	OPEC Panel				Non-OPEC Panel			
	Non		Trend		Non		Trend	
Test	Statistic	p-value	Statistic	p-value	Statistic	p-value	Statistic	p-value
CD_{LM}	158.4	0.000	182.7	0.000	118.7	0.000	69.52	0.011
CDp*	10.08	0.000	11.76	0.000	-1.29	0.196	-1.32	0.183
CD_{LMadj}*	29.74	0.000	34.08	0.000	18.95	0.000	4.64	0.000

Source: Authors' computations
*Two-sided test

Table 11 reports the results of the panel slope homogeneity test. The results provide strong evidence to reject the null hypothesis of slope homogeneity at 1% level of significance in the two panels, suggesting that the slope parameters in both panels are heterogeneous. This means following the second generation panel technique is more adequate[6].

Table 11: Panel Slope Homogeneity Test

Test	OPEC Panel	Non-OPEC Panel
chi2 (36)	163.56 ***	2061.13 ***
Prob>chi2	0.0000	0.0000

Source: Authors' computations
Note: *** indicates rejection of the null hypothesis at the 1%.

The result of the CIPS panel unit root test in Table 12 shows that except COP variable, which is integrated at a level I (0) all the remaining variables are integrated at first difference I(1). This, therefore, indicates a different order of variables cointegration in both panels.

Table 12: CIPS Panel Unit Root Tests

	OPEC Panel			
	Level I(0)		First difference I(1)	
	Constant	Constant & trend	Constant	Constant & trend
NRCA	-2.17	-2.54	-5.11***	-5.06***
COP	-3.45***	-3.42***	-5.37***	-5.39***
PR	-1.85	-2.09	-5.03***	-5.11***
ADP	-1.55	-2.53	-4.95***	-5.11***
	Non-OPEC Panel			
	Level I(0)		First difference I(1)	
	Constant	Constant & trend	Constant	Constant & trend
NRCA	-2.11	-2.27	-4.48***	-4.50***
COP	-5.20***	-4.30***	-4.53***	-4.45***
PR	-1.38	-2.43	-4.06***	-4.13***
ADP	-0.30	-1.34	-2.91***	-3.28**

Source: Authors' computations
Note: *** and ** indicates rejection of the null hypotheses at 1%, and 5% levels respectively.

6. Concerning heteroskedasticity and serial correlation. Breusch-Pagan test and Cook-Weisberg test are run to check for heteroskedasticity. The null hypothesis of constant variance is rejected at 1% based on the results of the two tests in both panels. For serial correlation, Wooldridge (2002) test used to check for panel-serial correlation. The null hypothesis of no first-order autocorrelation is rejected at 1% in the two panels.

Table 13 shows the results of the Westerlund (2008) cointegration test for the two panels when the test is carried out with constant. In the OPEC panel, the null hypothesis of no cointegration is rejected at 1% in group statistics test and at 5% in panel statistic test, while in the non-OPEC panel the null hypothesis of no cointegration is rejected just in the group statistics test at 10%. Therefore, we can conclude that the long-run relationship between the dependent and independent variables has existed.

Table 13: Westerlund (2008) Panel Cointegration Test

	OPEC Panel		Non-OPEC Panel	
	Statistic	P-value	Statistic	P-value
DHg	-2.614	0.004	-1.324	0.093
DHp	-2.168	0.015	1.221	0.887

Source: Authors' computations

We applied the ARDL (1, 1, 1, 1) model to estimate the PMG, MG and DFE for the two panels in order to obtain the coefficients of the relationship among the investigated variables. Consequently, we applied the Hausman (1978) test for pairwise comparison between the MG and PMG estimations in order to decide which method is the most preferable for an efficient result by testing the null hypothesis of homogenies restrictions. The result of the Hausman test provided in Table 14 shows that the null hypothesis cannot be rejected in the OPEC panel. This suggests that the PMG is preferable to the MG in the OPEC panel. In the non-OPEC panel, the hypothesis of the homogenies restrictions is rejected at 5%, indicating to select the result of the MG in the non-OPEC panel. However, in order to provide complete estimations for the panel ARDL model, we present the DFE estimations on the basis of reference and comparison.

Turning to the results of the panel ARDL based on the three estimation methods, there is evidence that the speed of adjustment coefficients are all negative and highly significant at 1% level of significance. This confirms the long-run relationship through the panel cointegration test in Table 13. In addition, the speeds of adjustment coefficients in the MG estimations in both panels are higher than the PMG estimations. In contrast, the speed of adjustment coefficients in MG estimations is (0.54) in non-OPEC countries is higher than the one in OPEC countries (0.45), suggesting a faster adjustment process from short run to the long run equilibrium.

Table 14: PMG, MG and DFE Estimations & Hausman Test Results

	OPEC Panel			Non-OPEC Panel		
	PMG	MG	DFE	PMG	MG	DFE
Speed of adjustment coefficients	- 0.353***	- 0.450***	- 0.357***	- 0.297***	- 0.541***	- 0.352***
Long-run coefficients						
COP	0.889***	0.566**	0.517***	0.253***	0.202	0.031
PR	- 0.286***	- 0.140	- 0.028	- 0.909***	- 0.454**	- 0.032
ADP	0.377***	0.287**	0.311***	1.333***	0.606**	0.451***
Short-run coefficients						
ΔCOP	0.997***	0.973***	0.959***	0.267	0.197	0.077
ΔPR	0.040	0.026	0.034	- 0.344**	- 0.292*	- 0.393***
ΔADP	0.362***	0.310**	0.386***	0.871**	0.778*	0.466***
Constant	- 0.089***	- 0.079***	- 0.087***	0.027	0.026	0.014
Hausman test	chi2(3)	Prob>chi2		chi2(3)	Prob>chi2	
MG vs PMG	1.93	0.587		9.46	0.023	
Preferred Method		PMG			MG	

Source: Authors' computations

Note: ***, **, and * indicates rejection of the null hypotheses at 1%, 5%, and 10% levels respectively

Beginning with the coefficients of crude oil price (COP) in Table 14, the estimations of the PMG for OPEC panel and the MG for non-OPEC panel show that, while the effect of the COP on NRCA in the OPEC countries is positive and statistically significant in both long-run ($\delta_1' = 0.88, \mathrm{p} < 0.01$) and short-run ($\delta_1' = 0.99, \mathrm{p} < 0.01$) respectively, its effect in non-OPEC countries is also positive in both long-run ($\delta_1' = 0.20, \mathrm{p} < 0.47$) and short-run ($\delta_1' = 0.197, \mathrm{p} < 0.453$) but statistically insignificant. Our result finds the relationship between the comparative advantage embodied in NRCA index and COP is consistent with the classical and neo-classical thoughts, which argue that a country tends to enjoy a comparative advantage when it has the ability to produce and export at a relatively lower cost. To this extent, the established relationship between COP and comparative advantage of crude oil in OPEC countries mainly reflects the relationship between COP, production and exports of crude oil as the NRCA index is calculated by post-trade data. The implication for this result is that as the COP increases, it will lead to more production and exportation of crude oil, which increases the comparative advantage of the country. This result is in support of the findings documented by Kaufmann, et al. (2004); Brémond, et al. (2012); Ratti and Vespignani (2015) that OPEC crude oil production significantly responds to an increase in COP.

The proven reserve variable (PR) represents the endowed natural resource of the crude oil that is already discovered and available for production. Basically, according to Harold Hotelling (1931), the price of a depletable (non-renewable) natural resource tends to be higher than marginal cost or equal to the interest rate, in order to compensate stock resources exhausted, even in a perfectly competitive market. This is known as Hotelling rent or scarcity rent (Krautkraemer, 1998; Hamilton, 2008).

Accordingly, the scarcity of crude oil as a depletable resource causes its price to rise (Frankel, 2010). Therefore, the established negative relationship between PR and the comparative advantage in our study is apparently due to the growth of PR i.e., crude oil abundance, which in turn leads to growth in the supply of crude oil. Consequentially, this will lead to an inverse relationship between PR and comparative advantage. Our results further suggest that PR has a negative and significant relationship with the comparative advantage in the long-term ($\delta_2' = -0.286, \mathrm{p} < 0.01$) based on the PMG estimation in OPEC countries and the MG estimation in non-OPEC countries ($\delta_2' = -0.45, \mathrm{p} < 0.05$). In the short run, based on the estimation of the PMG for the OPEC panel, our result reveals that the relationship between PR and comparative advantage is positive and statistically insignificant ($\delta_2' = 0.04, \mathrm{p} < 0.35$). However, the result of the relationship between PR and comparative advantage based on MG estimation for non-OPEC countries found to be negative in the short run ($\delta_2' = 0.29, \mathrm{p} < 0.10$). This, therefore, provides evidence to support that comparative advantage is negative and significantly affected by PR in the short run. This result concurs with the concept that a natural resource is one of the determinants of comparative advantage, in addition to a number of socioeconomic factors, such as institutions, production policy, human resources, transportation costs and technology (Yeats, 1985). However, the result is inconsistent with the findings documented by Heller (1976); Gunton (2003); Svaleryd and Vlachos (2005); Fourie (2009); Toit, et al. (2010); Hoang, et al. (2017); Balogh and Jambor (2017) that natural resources are positively related to the comparative advantage.

Lastly, the average of daily crude oil production (ADP), which expresses the capacity of crude oil production per day, has a positive and statistically significant effect on the comparative advantage in both groups of countries in the long ($\delta_3' = 0.377, \mathrm{p} < 0.01$) ($\delta_3' = 0.606, \mathrm{p} < 0.05$) and short run ($\delta_3' = 0.36, \mathrm{p} < 0.01$) ($\delta_3' = 0.77, \mathrm{p} < 0.10$). These results align with the finding of Yue and Hua (2002), that the rapid growth of domestic production capacity stimulates the value of export. Likewise, the finding of Vollrath, (1991) revealed that a positive relationship exists between comparative advantage and production intensity.

Moreover, the results of the robustness tests run by employing Pool OLS, Fixed Effect and Random Effect GLS regressions shown in Table 15 confirm the results obtained from the panel ARDL model in the OPEC panel, meaning that our findings are robust regarding this group of countries. However, these results confirm just the positive effect of the ADP in non-OPEC panel.

Table 15: Pooled OLS, Fixed Effect and Random Effect Results

	OPEC Panel		
	Pooled OLS	RE GLS	FE (within)
COP	0.647***	0.647***	0.647***
PR	-0.174*	-0.174*	-0.174*
ADP	0.318***	0.318***	0.318***
Constant	0.003	0.003	0.003
	Non-OPEC Panel		
	Pooled OLS	RE GLS	FE (within)
COP	0.088**	0.088**	0.088**
PR	-0.029	-0.029	-0.028
ADP	0.312***	0.312***	0.311***
Constant	0.014	0.014	0.014

Source: Authors' computations

Table 16 presents the outcomes obtained from the panel Granger causality test. The results reported bidirectional (two-way) Granger causality relationships detected between the investigated variables in both panels, where the null hypothesis of homogeneous non-causality is rejected in both panel at 1%, 5% and 10% level of significance as appear in the table. These results, therefore, support the earlier results of the panel ARDL which show that the three dependent variables have a significant relationship with the comparative advantage of crude oil production.

Table 16: Granger Causality Test

Independent variable	Dependent Variable	OPEC Panel		Non-OPEC Panel	
		Statistic	P-Value	Statistic	P-Value
COP	NRCA	1.68***	0.091	1.92***	0.054
NRCA	COP	1.44***	0.003	4.09***	0.000
PR	NRCA	-1.64*	0.09	3.18***	0.0015
NRCA	PR	-2.25***	0.024	2.28**	0.022
ADP	NRCA	-1.96*	0.049	2.39**	0.016
NRCA	ADP	-092**	0.035	3.35***	0.000

Source: Authors' computations
Note: ***, ** and * indicates rejection of the null hypotheses at 1%, 5% and 10% levels respectively. The variables NRCA, PR and ADP are in the first difference.

4.5 Conclusion and Policy Implications

This empirical study aimed at measuring the comparative advantage of crude oil and hence investigates the determinants of the comparative advantage of this industry. Therefore, two panels was prepared for a sample of 20 countries selected from the biggest crude oil producing countries, based on 10 OPEC countries and 10 non-OPEC countries so as to ensure a variety of production policies. The RCA for the sampled countries is calculated using the NRCA index due to its favorable characteristics in assessing and comparing the dynamics of the comparative advantage. Subsequently, the Panel ARDL model is applied through three methods to estimate the relationship between comparative advantage of crude oil and three explanatory variables (COP, PR, and ADP).

The empirical results obtained based on the NCRA computations demonstrated that all the OPEC countries enjoy a comparative advantage in producing crude oil. In contrast, just five non-OPEC countries (Russia, Norway, Mexico, Kazakhstan, and Oman) out of ten obtained a comparative advantage in producing crude oil. Neither the USA, nor China, nor Brazil, nor the UK has a comparative advantage in crude oil production. In addition, it is revealed that Canada's comparative advantage came to light only from 2006 onwards. These results support the (H-O) trade theory in all OPEC countries, as well as Canada, Russia, Norway and Kazakhstan, while the results of Brazil, the UK and the USA failed to corroborate with the H.O theory.

Concerning the determinants of the comparative advantage, the empirical findings indicated that the influence of the COP is positive in all estimations for OPEC and non-OPEC countries in the long run as well as in short run. However, the coefficients are only statistically significant for OPEC countries. Furthermore, the effect of natural resources (PR) on the comparative advantage of crude oil production is negative, suggesting a decline in comparative advantage as PR increases. This result is consistent with the idea of scarcity rent of Hotelling rent introduced by Harold Hotelling in 1931. There is also evidence for the positive effect of ADP on comparative advantage both in the long and short run for OPEC and non-OPEC countries. Furthermore, the result panel Granger causality test revealed feedback causality relationship between all the variables in the two panels.

Therefore, our findings provide new insights for policymakers of the sampled countries to have a proper knowledge of whether the sampled countries enjoy a comparative advantage in producing crude oil and to understand the factors that derive their comparative advantage in this sector. This will help governments and policymakers to target an appropriate factor to enhance this advantage in the countries that have no comparative advantage in producing crude oil, or to sustain this advantage in the countries that enjoy the comparative advantage in this production; to achieve sustainable growth and economic development using the financial returns from crude oil exports.

Chapter 5

CONCLUDING REMARKS

This dissertation comprehensively explores the comparative advantage of producing crude oil through measuring the comparative advantage of crude oil production and exploring the factors that govern the advantage of this commodity.

In chapter two, the comparative advantage of crude oil production was measured for 28 oil-producing countries, and further the determinants of this comparative advantage were investigated using five explanatory variables relative to the comparative advantage and Heckscher Ohlin (H-O) international trade theories. The results showed that not all the sampled countries seemingly have a comparative advantage in producing crude oil.

In the long term, all the investigated explanatory variables were found to be a key determinates of the comparative advantage of crude oil. Specifically, crude oil price, daily average of crude oil production and institutional quality all contribute significantly in increasing the comparative advantage of crude oil production, while domestic demand for crude oil and proven reserve decrease this advantage. In the short term, the impact of crude oil price and daily average of crude oil production remain the same. However, proven reserve, domestic demand for crude oil and institutional quality all have insignificant effect.

The third chapter of this dissertation focuses on the nexus between environmental performance and comparative advantage of producing crude oil by incorporating the role of institutional quality in 28 oil-producing countries. The empirical findings revealed that the environmental performance and institutional quality both are major factors of the comparative advantage of crude oil production along with some conventional determinants such as crude oil price, daily average of crude oil production, domestic demand for crude oil and proven reserve. Specifically, crude oil price, daily average of crude oil production and institutional quality all contribute significantly in increasing the comparative advantage of crude oil, while environmental performance, domestic demand for crude oil and proven reserve decrease this comparative advantage. Hence, the established negative effect of environmental performance on the comparative advantage of producing crude oil is in support of pollution haven hypothesis in resource-based industries. Further, the results confirmed negative-bidirectional relationship between environmental performance and comparative advantage of crude oil with vital role of institutional quality. Moreover, the environmental Kuznets curve (EKC) hypothesis is validated besides a substantial difference in the results between OPEC and non-OPEC countries is confirmed through a set of dummy variables.

Finally, the fourth chapter investigates the differences between OPEC and non-OPEC countries in regard of the comparative advantage in producing crude oil. While the entire OPEC sample was found to have a comparative advantage in crude oil production, just five of 10 non-OPEC countries were found to enjoy this advantage. The results further indicated that crude oil price, daily average of crude oil production and proven reserve all have the same effect that were found in the second and the third chapters. In the OPEC countries crude oil price and daily average of crude oil production positively affect the comparative advantage of producing crude oil both in the short term as well as in the long term, while proven reserve decline this advantage just in the long term. Similarly, in the non-OPEC countries both daily average of crude oil production and proven reserve also have the same effect as in the OPEC countries. Whereas, the price of crude oil in the non-OPEC countries has statistically insignificant effect in the short and the long term on the comparative advantage of producing crude oil.

Thus, the findings of this thesis filled the existing gap in the empirical literature of the comparative advantage of the crude oil, where the results revealed that not all oil-producing counties have an ability to produce crude oil at lower opportunity cost comparing to other producers.

Regarding the determinants of the comparative advantage of crude oil, the empirical findings proved that the effect of proven reserve (natural resource) is negative. This result suggests that an increase in the proven reserve decreases the comparative advantage of crude oil. However, these result contrary to the positive relationship established in the previous studies regarding other activities. The negative effect of the proven reserve may attributed to philosophy of Hotelling rent (1931) (scarcity rent) where crude oil abundance leads to growth in the supply of crude oil, which in turn leads to an inverse relationship between proven reserve and comparative advantage.

Concerning the relationship between the comparative advantage of crude oil and the environmental performance, the results showed a bidirectional negative relationship between the comparative advantage of crude oil and environmental performance with a vital role of Institutional quality in enhancing the comparative advantage of crude oil and improving the environmental performance. The results, further, confirmed the pollution haven hypothesis in resource-based industry as well as the environmental Kuznets curve (EKC) hypothesis.

As these results established from panel data analysis, further studies are needed on the basis of cross sections using time series analysis. Particularly for the capital-abundant countries that found have no a comparative advantage in crude oil production and for those countries with high environmental performance and which were found to have a comparative advantage in crude oil.

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APPENDICES

Appendix A: Properties Based Compression between the RCA Indices

Property	BRCA	LRCA	SRCA	WRCA	ARCA	NRCA
Distribution	0 , + ∞	-∞, +∞	-1, +1	-1 , +1	-1, +1	-0.25, +0.25
Symmetry	No	Yes	Yes	No	Yes	Yes
Normality	No	No	No	No	No	No
Mean	Inconstant	Inconstant	Inconstant	Constant across countries	Constant across countries	Constant across countries & commodities
Sum over sectors	-	0	-	-	-	0
Sum over countries	-	-	-	-	-	0
Independence from Aggregation level	No	No	No	No	Yes	Yes
Independence from reference group of countries	No	No	No	No	No	Yes
Comparability Cross-sector	No	?	No	?	No	Yes
Comparability Cross-country	No	?	No	?	Yes	Yes
Comparability Over-time	No	Yes	No	?	?	Yes

Source: Sanidas and Shin (2010) and Bebek (2017)

Appendix B: NRCA, Proven Reserve (PR), Crude Oil Production (PRO) and Crude Oil Consumption (CON) Compression

	Algeria				Angola				Azerbaijan				Brazil			
Year	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON
1990	25	9.2	1347.5	212.2	9.9	1.6	474.6	31.3	2.4	1.3	254.3	166.2	-6.4	4.5	650.5	1416.9
1991	22.5	9.2	1350.6	207.5	9.0	1.5	497.7	34.3	2.6	1.3	239.7	160.4	-5.4	4.8	643.4	1438.1
1992	20	9.2	1323.4	209.6	8.8	1.3	549.7	30.9	2.2	1.3	227.5	155.9	-3.6	5.0	652.6	1519.8
1993	17.6	9.2	1329.1	208.4	7.2	1.9	503.7	32.3	2.4	1.3	207.4	150.9	-3.5	5.0	667.4	1588.8
1994	14.3	10.0	1323.8	202.2	6.3	3.0	556.7	35.0	3.6	1.2	193.4	140.2	-3.9	5.4	691.7	1697.7
1995	13.2	10.0	1326.6	196.5	6.7	3.1	632.9	32.5	3.4	1.2	185.1	125.5	-3.2	6.2	714.9	1773.1
1996	16	10.8	1385.8	185.5	9.1	3.7	716.0	34.8	2.9	1.2	183.3	111.7	-3.5	6.7	808.4	1864.4
1997	14.5	11.2	1420.5	185.6	8.2	3.9	741.0	35.8	2.6	1.2	182.3	106.9	-3.4	7.1	869.4	1985.3
1998	10.2	11.3	1460.6	192.3	5.6	4.0	730.8	31.9	2.8	1.2	230.7	112.2	-1.4	7.4	1003.2	2056.0
1999	14.4	11.3	1515.4	185.5	8.0	5.1	745.1	39.0	3.8	1.2	278.7	107.4	-1.6	8.2	1132.4	2107.7
2000	20.6	11.3	1549.1	190.4	10.4	6.0	746.1	41.7	5.9	1.2	281.2	119.7	-2.6	8.5	1276.2	2029.5
2001	17.6	11.3	1534.2	197.6	8.9	6.5	742.0	48.1	6.2	1.2	300.2	78.7	-2.1	8.5	1339.1	2062.8
2002	17.8	11.3	1653.0	220.0	11.1	8.9	905.4	51.3	7.1	7.0	307.0	72.6	-2.3	9.8	1497.7	2044.6
2003	20.3	11.8	1826.3	228.9	11	8.8	869.6	61.3	8.0	7.0	307.9	83.9	-2.6	10.6	1557.8	1984.1
2004	23.2	11.8	1920.7	238.3	13	9.0	1106.4	64.0	8.6	7.0	308.7	90.5	-3.6	11.2	1542.8	2064.8
2005	28.3	12.3	1989.9	249.3	19.6	9.1	1269.0	67.3	8.4	7.0	444.9	106.2	-4.5	11.8	1705.6	2123.3
2006	28.3	12.3	1979.5	257.6	22.3	9.3	1401.4	74.8	8.8	7.0	646.2	96.1	-3.4	12.2	1806.1	2152.2
2007	28.7	12.2	1992.3	286.0	28.7	9.5	1656.0	76.9	9.9	7.0	875.5	91.1	-2.4	12.6	1831.1	2308.3
2008	28.9	12.2	1969.3	308.7	35.4	9.5	1876.3	80.8	9.9	7.0	915.8	74.3	-2.6	12.8	1897.2	2481.3
2009	22	12.2	1774.9	326.5	29.8	9.5	1753.8	82.6	8.9	7.0	1026.7	72.6	-1.0	12.9	2029.0	2497.9
2010	23.5	12.2	1689.2	326.9	30.2	9.1	1812.3	87.9	11.2	7.0	1036.7	72.2	0.8	14.2	2136.9	2716.3
2011	24.7	12.2	1641.5	349.5	32.9	9.1	1670.4	84.4	11.4	7.0	932.1	88.6	-0.4	15.0	2178.8	2838.7
2012	22.8	12.2	1536.8	369.8	35.1	9.1	1734.1	84.5	10	7.0	882.3	92.1	-1.0	15.3	2144.8	2915.1
2013	20.9	12.2	1485.2	387.4	33	9.0	1747.6	149.2	9.9	7.0	888.4	100.8	-4.0	15.6	2109.9	3124.3
2014	19.3	12.2	1589.1	400.6	28.3	8.4	1668.1	147.2	9.0	7.0	861.2	99.3	-0.4	16.2	2341.4	3242.3
2015	12.2	12.2	1557.7	422.5	18.5	9.5	1772.2	141.8	5.1	7.0	850.8	99.5	0.4	13.0	2525.0	3181.1
2016	11	12.2	1577.0	411.5	15.7	9.5	1755.0	122.0	3.9	7.0	837.5	97.8	0.6	12.6	2607.8	3012.7

	Egypt				Gabon				Indonesia				Iran			
Year	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON
1990	1.6	3.5	897.1	465.0	5.3	0.9	270.2	6.6	12.7	5.4	1539.0	652.3	45.2	92.9	3270.2	1003.9
1991	1.5	3.5	895.7	457.2	4.7	0.9	294.6	7.5	11.6	5.9	1669.0	692.1	41.5	92.9	3499.6	1066.4
1992	1.6	3.4	906.0	444.8	4.4	0.8	288.6	11.3	10.3	5.6	1579.0	745.1	38.9	92.9	3523.0	1136.3
1993	1.7	3.4	940.7	427.4	3.9	0.7	304.9	11.7	8.7	5.2	1588.0	785.8	32.8	92.9	3712.2	1233.6
1994	1.5	3.9	921.4	426.7	3.8	1.4	337.2	10.9	7.9	5.0	1589.0	809.0	30.9	94.3	3730.0	1283.1
1995	1.2	3.8	923.5	462.6	4.0	1.5	355.6	11.1	6.6	5.0	1578.0	864.7	28.9	93.7	3743.8	1286.5
1996	1.3	3.8	893.8	488.4	4.7	2.8	364.5	11.3	6.4	4.7	1580.0	923.6	36	92.6	3758.6	1339.4
1997	0.9	3.7	872.5	517.9	4.2	2.7	364.4	12.8	5.8	4.9	1557.0	1024.0	27.8	92.6	3776.5	1391.0
1998	0.1	3.8	856.7	545.5	2.8	2.6	337.4	13.5	3.5	5.1	1520.0	977.7	18.5	93.7	3854.7	1345.6
1999	0.3	3.8	827.5	560.0	3.4	2.6	340.0	13.1	4.5	5.2	1408.0	1022.3	28.1	93.1	3603.4	1356.4
2000	0.1	3.6	778.7	551.9	2.7	2.4	276.0	13.2	3.8	5.1	1455.6	1147.8	37.4	99.5	3852.3	1403.8
2001	0.1	3.7	758.4	537.1	3.2	2.4	262.0	13.3	4.6	5.1	1387.0	1165.2	33	99.1	3825.4	1421.7
2002	0.1	3.5	751.4	524.4	3.1	2.4	256.0	13.3	3.5	4.7	1289.5	1209.1	27.7	130.7	3617.8	1435.1
2003	0.0	3.5	749.5	540.1	3.3	2.3	274.0	12.9	3.0	4.7	1175.6	1229.8	32.5	133.3	4084.7	1456.4
2004	-0.1	3.6	701.1	556.0	3.5	2.2	273.0	13.3	2.1	4.3	1129.7	1307.5	34.8	132.7	4217.4	1495.6
2005	-0.3	3.7	671.8	616.6	3.7	2.1	270.3	15.0	1.7	4.2	1095.7	1302.6	46.8	137.5	4218.2	1651.1
2006	-0.2	3.7	678.7	601.2	3.4	2.2	241.9	15.1	0.2	4.4	1017.8	1243.9	43.1	138.4	4293.4	1801.0
2007	-0.1	4.1	698.4	641.6	3.3	2.0	245.6	16.1	0.4	4.0	971.8	1317.8	44.7	138.2	4359.0	1837.7
2008	-0.1	4.2	715.3	685.6	4.0	2.0	239.6	16.0	0.0	3.7	1005.6	1286.5	50.4	137.6	4420.6	1925.2
2009	-0.1	4.4	730.0	724.7	2.9	2.0	241.0	15.6	-0.2	4.3	994.3	1316.6	40	137.0	4291.8	1919.0
2010	-0.1	4.5	724.7	765.8	3.4	2.0	249.0	19.4	-0.9	4.2	1003.0	1411.3	42.2	151.2	4430.1	1790.7
2011	0.1	4.3	714.3	720.2	4.2	2.0	246.2	20.3	-2.2	3.7	952.3	1589.0	56.5	154.6	4472.5	1825.6
2012	0.2	4.2	715.3	746.9	4.4	2.0	241.6	21.6	-2.8	3.7	917.8	1640.2	49.4	157.3	3820.3	1849.3
2013	0.3	3.9	709.8	755.9	3.9	2.0	226.4	23.5	-2.8	3.7	882.2	1663.0	27.1	157.8	3617.0	2011.2
2014	0.5	3.7	714.4	805.9	3.8	2.0	225.9	23.6	-2.2	3.6	852.5	1680.7	24.5	157.5	3723.6	1952.8
2015	0.6	3.5	726.2	832.8	2.8	2.0	224.7	24.4	-0.6	3.6	840.8	1564.3	14.3	158.4	3861.8	1766.1
2016	0.6	3.4	691.4	854.1	2.5	2.0	220.2	25.2	-0.4	3.3	882.0	1580.0	23.5	157.2	4602.4	1722.4

	Canada				China				Colombia				Ecuador			
Year	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON
1990	-12.1	40.3	1967.7	1747.3	-3.6	16.0	2777.6	2296.9	1.9	2.0	446.0	205.8	3.4	1.4	292.0	91.5
1991	-6.1	40.1	1983.5	1659.2	-3.6	15.5	2831.4	2490.6	2.1	1.9	430.0	211.1	2.9	1.5	307.0	102.8
1992	-2.5	39.6	2065.6	1688.9	-3.6	15.2	2844.7	2704.9	2.2	3.2	442.0	231.0	3.3	3.2	328.0	99.7
1993	-2.7	39.5	2189.0	1697.3	-4.4	16.4	2892.4	3013.5	2.0	3.2	458.0	245.6	3.1	3.7	353.0	104.2
1994	-5.1	48.1	2281.3	1726.1	-8.5	16.3	2933.6	3068.8	1.5	3.1	460.0	253.7	2.8	3.5	388.0	113.2
1995	-2.0	48.4	2402.1	1848.2	-8.3	16.4	2992.6	3342.2	3.0	3.0	591.0	266.2	2.8	3.4	395.0	111.0
1996	-3.5	48.9	2479.9	1889.2	-9.0	16.4	3174.7	3659.9	3.9	2.8	635.0	274.5	2.8	3.5	393.0	123.2
1997	-3.0	48.8	2587.6	1968.9	-10.6	17.0	3215.8	4007.4	3.4	2.6	667.0	280.5	2.0	3.7	397.0	140.5
1998	-1.6	49.8	2672.4	2002.3	-8.2	17.4	3216.8	4139.0	3.3	2.5	775.0	275.2	1.5	4.1	385.0	143.3
1999	-6.3	181.6	2604.4	2061.2	-14	15.1	3217.6	4387.0	5.3	2.3	838.0	245.5	2.3	4.4	383.0	130.1
2000	-5.3	181.5	2703.4	2042.7	-19.8	15.2	3256.8	4696.9	5.1	2.0	687.0	239.0	3.3	4.6	403.0	136.5
2001	-4.9	180.9	2728.0	2093.9	-20.1	15.4	3310.1	4809.7	3.2	1.8	604.0	225.4	2.7	4.6	410.0	141.1
2002	-2.9	180.4	2858.2	2172.3	-24.8	15.5	3351.0	5205.3	3.1	1.6	578.0	221.3	2.8	5.1	394.0	140.3
2003	-0.5	179.9	3003.5	2228.2	-30.2	15.5	3405.6	5795.1	2.4	1.5	541.0	229.6	3.1	5.1	420.0	144.2
2004	0.4	179.6	3079.9	2308.6	-37.8	18.3	3485.8	6754.9	2.2	1.5	528.3	228.3	4.2	5.2	528.0	154.6
2005	-1.9	180.0	3040.9	2277.5	-52	18.2	3642.0	6899.5	2.4	1.5	526.2	236.9	4.9	5.2	534.0	169.2
2006	2.3	179.4	3208.4	2275.1	-61.7	20.2	3710.5	7431.5	2.2	1.5	529.3	236.5	5.5	5.2	537.7	179.7
2007	5.2	178.8	3290.2	2342.1	-65.2	20.8	3741.7	7808.2	2.4	1.5	531.4	234.3	5.2	6.4	513.1	182.7
2008	14.1	176.3	3207.0	2297.4	-78.7	21.2	3814.0	7941.2	3.7	1.4	588.4	250.6	6.3	6.5	506.7	188.1
2009	12.8	175.0	3202.4	2174.2	-65	21.6	3805.4	8278.4	4.7	1.4	670.6	232.0	4.8	6.5	488.1	190.7
2010	14.3	174.8	3332.1	2306.3	-76.9	23.3	4077.0	9436.0	6.9	1.9	786.1	258.3	5.5	7.2	488.1	220.4
2011	16.7	174.2	3514.8	2381.5	-90.7	23.7	4074.2	9796.2	10	2.0	915.3	276.7	6.1	8.2	500.6	226.1
2012	18.4	173.7	3740.2	2341.9	-102.2	24.4	4155.2	10230.2	11.6	2.2	944.1	296.6	6.4	8.2	504.6	233.0
2013	22.1	173.0	4000.4	2383.5	-100.1	24.7	4216.4	10734.4	12.3	2.4	1004.0	298.0	6.5	8.8	527.4	247.4
2014	27.8	172.2	4270.5	2399.5	-95.4	25.2	4246.0	11208.9	11.6	2.4	990.4	316.5	6.1	8.3	556.6	260.4
2015	18.3	171.5	4389.1	2348.0	-68.4	25.6	4308.8	11985.7	6.8	2.3	1005.6	329.9	3.5	8.3	543.1	254.2
2016	14.9	170.6	4470.2	2400.6	-54.2	25.7	3999.2	12301.7	4.3	2.0	885.9	339.1	3.0	8.3	548.4	239.8

	Iraq				Kazakhstan				Kuwait				Libya			
Year	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON
1990	25.9	100.0	2148.9	312.7	2.5	5.2	570.7	440.5	17.2	964.0	66.6	97.0	28.6	22.8	1424.0	144.0
1991	1.0	100.0	285.4	226.3	2.1	5.2	588.7	444.9	2.4	185.0	71.0	96.5	28	22.8	1439.0	148.0
1992	1.3	100.0	531.3	356.4	1.2	5.2	568.9	414.9	16.1	1077.0	100.3	96.5	24.1	22.8	1473.0	146.2
1993	1.1	100.0	455.3	503.1	0.4	5.2	507.4	320.0	25.4	1945.0	103.2	96.5	20	22.8	1402.0	145.6
1994	1.0	100.0	505.3	574.3	3.6	5.3	445.9	247.1	24.2	2085.0	136.4	96.5	16.4	22.8	1431.0	176.6
1995	0.9	100.0	530.3	558.9	3.4	5.3	450.4	242.4	23.5	2130.0	141.7	96.5	15.1	29.5	1439.0	198.1
1996	1.3	112.0	580.3	594.4	1.9	5.3	493.1	204.9	26.3	2129.0	138.3	96.5	17.7	29.5	1452.0	200.3
1997	8.7	112.5	1165.8	713.2	2.6	5.3	556.9	207.0	24.2	2137.0	154.3	96.5	16	29.5	1491.0	200.1
1998	9.5	112.5	2120.8	474.3	2.8	5.4	558.5	172.1	15.7	2232.0	229.6	96.5	10.4	29.5	1480.0	205.0
1999	21.3	112.5	2609.8	347.0	3.8	5.4	655.6	143.9	19.4	2085.0	255.8	96.5	13.7	29.5	1425.0	210.6
2000	29.2	112.5	2613.0	461.4	5.9	5.4	740.2	146.9	26.8	2244.2	256.9	96.5	18.1	36.0	1474.6	203.4
2001	24.3	115.0	2522.0	533.1	6.2	5.4	841.5	156.8	23.1	2186.2	264.6	96.5	16.8	36.0	1427.7	214.5
2002	18.6	115.0	2116.0	501.6	7.1	5.4	992.6	151.4	20.7	2028.4	285.1	96.5	14	36.0	1374.9	215.9
2003	9.5	115.0	1344.0	475.1	8.5	9	1080.6	160.4	24	2370.3	333.7	99.0	17.1	39.1	1485.0	224.0
2004	18.3	115.0	2030.0	515.6	11.2	9	1247.9	188.5	27.5	2519.3	373.8	101.5	18.8	39.1	1622.3	232.8
2005	21.1	115.0	1833.0	496.7	14.8	9	1294.6	193.2	37.8	2668.2	410.6	101.5	25.1	41.5	1744.7	231.1
2006	23.4	115.0	1999.0	506.8	17.2	9	1369.9	221.0	40.7	2735.4	377.6	101.5	28.5	41.5	1815.2	230.4
2007	26.3	115.0	2143.2	489.7	17.7	30	1415.0	240.6	39.2	2659.6	383.0	101.5	28.4	43.7	1819.7	233.6
2008	36.1	115.0	2428.0	480.6	23.2	30	1485.2	240.4	46.7	2783.6	405.8	101.5	34.9	44.3	1819.7	253.2
2009	29.5	115.0	2445.6	535.8	18.7	30	1609.5	198.1	36.4	2498.5	455.0	101.5	26.6	46.4	1652.0	272.9
2010	31.5	115.0	2468.9	570.1	21.6	30	1675.7	210.5	37.6	2559.7	470.1	101.5	28.9	47.1	1658.8	306.1
2011	41.9	143.1	2773.3	629.2	26.3	30	1684.1	242.7	48.6	2913.1	444.7	101.5	9.4	48.0	478.8	221.3
2012	47.2	140.3	3078.5	665.8	26.5	30	1664.1	245.0	54.2	3168.6	490.9	101.5	30.2	48.5	1509.2	220.0
2013	44.3	144.2	3102.5	716.0	27.1	30	1736.7	260.4	53	3128.7	508.4	101.5	22	48.4	988.6	250.0
2014	41.7	143.1	3238.6	681.3	25.5	30	1709.6	261.9	46.4	3101.1	446.0	101.5	10.1	48.4	498.0	222.2
2015	28.5	142.5	3985.9	687.0	14.9	30	1694.8	284.2	27.9	3064.7	456.5	101.5	6.4	48.4	431.9	211.1
2016	26.5	148.8	4422.9	758.0	11.3	30	1655.0	301.8	25	3145.1	452.8	101.5	5.8	48.4	426.1	207.6

	Malaysia				Mexico				Nigeria				Norway			
Year	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON
1990	5.5	3.6	622.0	262.6	20.6	51.3	2940.8	1610.8	35.9	17.1	1786.7	162.3	27.9	8.6	1716.0	202.0
1991	5.0	3.7	648.0	284.6	17	50.9	3099.6	1686.5	32.4	20.0	1963.1	195.4	30.6	8.8	1955.0	187.3
1992	4.6	5.1	657.0	309.0	14.2	51.2	3098.3	1708.3	30.3	21.0	2032.0	247.4	31.8	9.7	2217.0	191.9
1993	3.0	5.0	645.0	345.7	11.6	50.8	3115.3	1714.9	28.4	21.0	2018.2	216.1	30.7	9.6	2377.0	204.8
1994	-0.3	5.2	657.0	385.5	9.3	49.8	3136.0	1824.3	25.6	21.0	1933.9	166.4	28.2	9.7	2693.0	207.8
1995	-0.9	5.2	704.0	403.8	8.2	48.8	3054.8	1722.4	22.4	20.8	1948.6	194.7	27.6	10.8	2903.0	203.7
1996	-1.5	5.0	716.0	445.4	11.8	48.5	3270.1	1744.9	27.6	20.8	1971.1	209.1	36.4	11.7	3232.0	216.6
1997	-1.5	5.0	714.0	511.8	10	47.8	3408.6	1783.9	25.8	20.8	1977.7	216.8	32.3	12.0	3280.0	220.0
1998	-0.4	4.7	725.0	445.0	5.2	21.6	3498.6	1881.0	16.1	22.5	2023.0	207.5	20.7	11.7	3138.0	221.1
1999	-1.8	5.0	691.0	489.4	5.6	21.5	3351.7	1874.4	22	29.0	1894.5	198.8	28	10.9	3139.0	218.4
2000	-3.0	4.5	728.0	494.5	8.0	20.2	3455.9	1951.9	29.1	29.0	2174.9	219.0	40.6	11.4	3346.0	201.6
2001	-2.5	4.5	707.6	521.5	5.6	18.8	3568.1	1925.0	26.6	31.5	2158.0	250.6	39.2	11.6	3418.0	223.3
2002	-2.8	4.5	745.8	588.1	7.2	17.2	3592.6	1848.0	25.2	34.3	1951.7	245.9	35.4	10.4	3333.0	215.5
2003	-2.2	4.8	763.1	620.3	10.4	16.0	3794.7	1900.7	30.3	35.3	2299.6	234.5	33.9	10.1	3264.0	231.6
2004	-1.8	5.2	778.5	633.1	11	14.8	3830.2	1975.2	37.6	35.9	2487.5	246.4	35.3	9.7	3179.9	220.9
2005	-2.4	5.3	745.4	637.4	12	13.7	3765.6	2017.4	44.2	36.2	2482.9	262.7	38.1	9.7	2960.9	223.7
2006	-3.2	5.4	699.9	659.8	12.5	12.8	3689.1	2008.1	41.8	37.2	2372.1	238.1	34.5	8.5	2772.2	229.2
2007	-2.6	5.5	729.8	701.2	12.5	12.2	3478.5	2088.9	33.3	37.2	2207.5	218.8	31.8	8.2	2550.6	237.5
2008	-3.0	5.5	731.2	672.3	10.7	11.9	3165.3	2080.4	41.6	37.2	2173.8	242.8	32	7.5	2466.3	227.6
2009	-2.9	3.6	691.0	678.6	8.0	11.9	2978.5	2021.3	30.9	37.2	2212.2	233.4	25.8	7.1	2349.2	237.3
2010	-3.5	3.7	726.4	689.2	9.0	11.7	2959.4	2039.7	40.5	37.2	2534.4	270.6	25.2	6.8	2136.6	235.0
2011	-5.0	3.7	660.4	725.3	10.5	11.4	2940.3	2065.1	44.1	36.2	2462.8	311.4	25.1	6.9	2039.2	239.0
2012	-5.7	3.7	662.1	758.6	7.2	11.4	2911.1	2083.0	48	37.1	2413.2	343.6	22.1	7.5	1917.4	235.5
2013	-4.9	3.8	625.5	803.2	5.8	11.1	2874.8	2034.2	44.5	37.1	2280.2	384.9	19.8	7.0	1837.8	243.2
2014	-3.9	3.6	649.7	801.0	2.9	10.8	2784.2	1959.7	37.6	37.4	2278.4	396.1	18.9	6.5	1888.9	232.4
2015	-1.8	3.6	698.3	789.4	-0.1	8.0	2586.5	1939.3	24	37.1	2203.5	407.8	12.3	8.0	1945.9	237.4
2016	-1.3	3.6	704.3	799.2	0.2	7.2	2455.8	1977.2	16.7	37.5	1903.1	393.1	12.1	7.6	1994.7	221.3

	Oman				Qatar				Russia				Saudi			
Year	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON
1990	13.2	4.4	695.0	41.9	8.8	3.0	433.8	43.0	23.7	116.1	10342.4	5042.3	108.1	260.3	7105.0	1136.3
1991	11.2	4.4	716.0	67.0	7.8	3.0	419.6	39.0	23.7	116.1	9263.7	4917.1	119.8	260.9	8820.0	1190.6
1992	11.7	4.7	748.0	59.2	7.4	3.1	495.3	40.3	17.8	116.1	7978.2	4698.9	120.6	261.2	9098.0	1155.4
1993	10.7	5.0	785.0	57.0	7.3	3.1	460.3	41.2	21	115.1	7118.9	3928.4	100.7	261.4	8962.0	1166.5
1994	9.4	5.1	819.0	50.6	6	3.5	451.4	43.6	23.3	115.1	6370.7	3486.0	88.1	261.4	9084.0	1403.3
1995	8.9	5.2	868.0	55.3	5.8	3.7	460.9	45.5	20.1	113.6	6235.8	3058.0	84.4	261.5	9092.1	1354.3
1996	10.6	5.3	897.0	53.3	7.1	3.7	568.0	47.9	20.9	113.6	6061.6	2624.0	100.6	261.4	9244.2	1400.5
1997	10	5.4	909.0	47.6	8.5	12.5	692.1	50.5	20.6	113.1	6170.7	2630.1	95.6	261.5	9427.6	1428.0
1998	6.5	5.4	905.0	48.1	6.1	13.5	701.4	51.8	13.8	113.1	6110.0	2489.8	60.1	261.5	9448.6	1509.1
1999	9.4	5.7	904.7	60.4	8.3	13.1	723.3	51.2	19.1	112.1	6118.8	2567.8	79.0	262.8	8800.1	1565.6
2000	12.7	5.8	954.8	64.1	11.3	16.9	853.1	49.6	27.6	112.1	6583.5	2540.0	104.3	262.8	9469.7	1626.9
2001	11.5	5.9	955.8	71.7	10.5	16.8	857.8	61.6	30.2	111.3	7106.6	2627.7	92.0	262.7	9188.1	1746.0
2002	10.7	5.7	897.4	83.6	9.9	27.6	803.2	73.1	34.4	109.7	7755.7	2543.5	93.7	262.8	8907.4	1809.6
2003	10.2	5.6	819.5	80.3	10.8	27.0	949.2	84.5	39.6	107.8	8603.4	2652.6	103.4	262.7	10140.9	1909.6
2004	9.1	5.6	779.7	78.2	11.7	26.9	1082.2	92.1	48.6	105.5	9335.7	2619.4	113.8	264.3	10457.9	2056.0
2005	11.4	5.6	774.3	87.5	15.2	27.9	1151.2	109.0	59.5	104.4	9598.3	2647.3	143.3	264.2	10931.3	2203.2
2006	10.6	5.6	737.7	91.9	13.4	27.4	1241.2	137.5	60.8	104.0	9836.8	2762.4	145.0	264.3	10670.9	2274.0
2007	9.1	5.6	710.4	90.1	14.2	27.3	1266.8	148.2	63.3	106.4	10061.7	2780.2	135.8	264.2	10267.7	2406.6
2008	11.6	5.6	756.8	122.6	34	26.8	1437.8	177.5	68.4	106.4	9969.3	2860.9	157.9	264.1	10662.7	2622.1
2009	9.7	5.5	812.5	119.0	20.6	25.9	1421.3	172.8	58.7	105.6	10157.2	2774.7	119.6	264.6	9663.3	2913.6
2010	12	5.5	864.6	135.5	25.1	24.7	1637.6	190.6	65.1	105.8	10382.7	2877.8	129.8	264.5	10074.6	3205.6
2011	13.1	5.5	884.9	146.1	29.2	23.9	1834.5	245.7	70.1	105.7	10538.2	3073.8	159.0	265.4	11143.7	3294.1
2012	14.3	5.5	918.5	157.3	28.8	25.2	1939.1	256.7	73.5	105.5	10660.1	3119.3	166.9	265.9	11634.5	3461.0
2013	14.8	5.0	941.9	178.2	27.3	25.1	2002.1	287.4	69.9	105.0	10808.9	3134.9	157.0	265.8	11393.1	3451.3
2014	16.6	5.2	943.5	184.7	25.1	25.7	1985.4	293.2	62.1	103.2	10860.5	3300.9	138.4	266.6	11504.7	3752.7
2015	9.7	5.3	981.1	185.6	15	25.2	1958.0	315.9	44.3	102.4	11009.2	3161.7	87.2	266.5	11994.3	3875.3
2016	7.5	5.4	1004.3	191.4	13	25.2	1969.7	343.1	38.5	106.2	11269.4	3193.2	79.4	266.2	12401.8	3938.6

	UAE				UK				USA				Venezuela			
Year	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON	NRCA	PR	PRO	CON
1990	38.5	98.1	1984.6	300.5	-10.5	4.0	1932.8	1750.7	-79.2	33.8	8914.3	16988.2	37.2	60.1	2244.0	427.9
1991	37.9	98.1	2274.4	365.4	-6.9	4.2	1933.6	1751.0	-70.4	32.1	9075.5	16713.4	33.5	62.6	2501.0	412.7
1992	35.7	98.1	2494.7	366.7	-3.4	4.6	1995.9	1771.1	-57.8	31.2	8868.1	17032.8	29.1	63.3	2499.0	488.1
1993	30.4	98.1	2438.3	381.6	0.5	4.5	2134.8	1788.6	-55.2	30.2	8582.7	17236.2	28	64.4	2592.0	450.2
1994	25.4	98.1	2462.5	399.0	0.5	4.3	2694.4	1782.6	-55.1	29.6	8388.6	17718.6	25.7	64.9	2752.0	498.6
1995	23.6	98.1	2444.0	399.7	0.4	4.5	2769.2	1765.8	-49.3	29.8	8321.6	17724.8	25.9	66.3	2959.0	484.0
1996	26.1	97.8	2501.3	385.3	-1.5	5.0	2755.1	1805.7	-58.9	29.8	8294.5	18309.4	33.5	72.7	3137.0	403.3
1997	25.9	97.8	2521.7	392.9	-4.5	5.2	2721.4	1763.0	-57.6	30.5	8268.6	18620.6	32.6	74.9	3321.1	432.1
1998	19.5	97.8	2610.1	391.1	-2.2	5.1	2834.5	1757.4	-39.7	28.6	8010.8	18917.2	22.3	76.1	3447.3	474.2
1999	24.9	97.8	2413.8	383.2	-2.3	5.0	2931.5	1743.0	-53.4	29.7	7731.5	19518.9	29.3	76.8	3095.1	506.8
2000	36.5	97.8	2598.9	380.6	-0.9	4.7	2695.6	1712.9	-71.7	30.4	7731.6	19701.4	40.7	76.8	3111.6	510.5
2001	35	97.8	2540.7	381.0	3.6	4.5	2503.2	1714.3	-60.9	30.4	7669.4	19648.6	33.3	77.7	3174.4	572.2
2002	31.4	97.8	2366.3	413.1	2.5	4.5	2490.4	1710.3	-56.9	30.7	7625.1	19760.9	31.4	77.3	2975.1	602.7
2003	34.2	97.8	2722.5	453.9	-0.4	4.3	2283.3	1725.6	-53.3	29.4	7367.3	20033.0	27.5	77.2	2868.6	506.4
2004	36.7	97.8	2821.6	485.4	-2.7	4.0	2052.2	1760.3	-53.6	29.3	7250.0	20731.5	33.6	79.7	3305.9	544.7
2005	44.8	97.8	2945.5	501.9	-7.4	3.9	1834.1	1828.4	-63.9	29.9	6899.8	20802.2	33.8	80.0	3302.1	605.8
2006	48.9	97.8	3134.5	539.5	-8.6	3.6	1658.8	1813.4	-67.8	29.4	6824.9	20687.4	35.6	87.3	3339.7	667.5
2007	43.6	97.8	3094.3	576.1	-4.8	3.4	1651.2	1752.3	-63.1	30.5	6859.7	20680.4	41.5	99.4	3237.1	640.0
2008	50.3	97.8	3113.1	602.8	-5.4	3.1	1548.8	1719.8	-71.8	28.4	6784.0	19490.4	50.3	172.3	3228.2	715.9
2009	44.1	97.8	2783.4	602.8	-2.3	2.8	1468.9	1645.7	-57.2	30.9	7263.0	18771.4	40.5	211.2	3037.8	726.2
2010	38.8	97.8	2914.6	653.9	-1.7	2.8	1355.5	1623.3	-62	35.0	7549.2	19180.1	38	296.5	2841.6	725.1
2011	47.2	97.8	3285.0	733.2	-6.7	3.1	1111.9	1590.1	-70.5	39.8	7858.8	18882.1	44.3	297.6	2755.0	737.1
2012	29.4	97.8	3430.1	771.8	-5.0	3.0	946.3	1533.3	-76.5	44.2	8903.6	18490.2	46.8	297.7	2703.7	791.6
2013	29.4	97.8	3543.1	849.1	-7.0	3.0	864.5	1518.0	-69.3	48.5	10071.2	18961.1	42.3	298.4	2680.4	781.7
2014	32.1	97.8	3598.9	878.5	-3.7	2.8	852.5	1517.7	-59.6	55.0	11768.2	19105.6	35.4	300.0	2692.5	719.5
2015	22.8	97.8	3873.3	949.0	-2.0	2.5	963.4	1560.7	-39.8	48.0	12750.3	19530.9	20.3	300.9	2630.9	636.5
2016	21	97.8	4019.9	1002.6	-1.2	2.3	1012.6	1592.4	-31.4	50.0	12365.8	19687.2	15.3	301.8	2386.6	539.1

Appendix C: Principal Component Analysis

Country	Eigenvalue	Proportion	Country	Eigenvalue	Proportion
Algeria	1.808	0.552	Kuwait	1.983	0.594
Angola	1.711	0.686	Libya	2.590	0.647
Azerbaijan	1.991	0.757	Malaysia	1.969	0.592
Brazil	2.726	0.771	Mexico	2.222	0.655
Canada	1.268	0.631	Nigeria	2.370	0.692
China	2.740	0.685	Norway	2.384	0.596
Colombia	1.882	0.570	Oman	2.688	0.672
Ecuador	1.709	0.567	Qatar	1.853	0.463
Egypt	1.851	0.562	Russia	2.665	0.666
Gabon	2.399	0.699	Saudi	2.230	0.557
Indonesia	1.493	0.563	UAE	2.397	0.599
Iran	1.680	0.550	UK	1.409	0.649
Iraq	1.811	0.572	USA	1.736	0.680
Kazakhstan	2.340	0.615	Venezuela	2.640	0.660

Note: Eigenvalue and Proportion reported just for 1 component

Appendix D: NRCA and EPI Comparison

Country	Index	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Algeria	NRCA	48.87	49.27	49.25	49.23	50.08	49.65	49.57	49.79	49.89	50.02	48.56	49.7	50.08
	EPI	17.8	20.3	23.2	28.3	28.3	28.7	28.9	22	23.5	24.7	22.8	20.9	19.3
Angola	NRCA	11.1	11	13	19.6	22.3	28.7	35.4	29.8	30.2	32.8	35.1	33	28.3
	EPI	26.3	26.72	27	27.33	27.76	27.85	27.56	28.18	28.62	28.63	47.57	37.29	28.69
Azerbaijan	NRCA	2.1	2.2	2.3	1.8	2.8	2	24.9	8.8	11.2	11.4	10	9.9	9
	EPI	51.37	52.82	54.42	55	55.21	55.34	55.7	55.57	55.67	55.38	43.11	54.73	55.47
Brazil	NRCA	-2.3	-2.6	-3.6	-4.5	-3.4	-2.4	-2.6	-1	0.8	-0.4	-1	-4	-0.4
	EPI	51.07	50.83	51.19	51.57	51.61	51.69	52.12	52.52	52.71	52.89	60.9	60.9	52.97
Canada	NRCA	-2.9	-0.5	0.3	-1.9	2.3	5.2	14.1	12.8	14.3	16.7	18.4	22.1	27.8
	EPI	71.3	71.74	71.81	72.12	72.12	72.44	72.87	72.93	73.03	73.07	58.41	60.7	73.14
China	NRCA	-24.8	-30.2	-37.8	-52	-61.7	-65.2	-78.7	-65	-76.9	-90.7	-102	-100	-95.4
	EPI	41.91	42.06	42.55	42.83	43.08	42.76	44	42.97	43.13	43.02	42.24	43.09	43
Colombia	NRCA	3	2.4	2.2	2.4	2.2	2.4	3.7	4.7	6.9	10	11.6	12.3	11.6
	EPI	48.4	48.73	49.13	50.01	50.18	50.24	50.37	50.56	50.64	50.69	62.33	60.32	50.77
Ecuador	NRCA	2.8	3.1	4.2	4.9	5.5	5.2	6.3	4.8	5.5	6.1	6.4	6.5	6.1
	EPI	54.45	55.26	56.61	56.94	56.68	57.02	57.55	57.93	58.18	58.57	60.55	59.7	58.54
Egypt	NRCA	0.1	0	-0.1	-0.3	-0.2	-0.1	-0.1	-0.1	-0.1	0.1	0.2	0.3	0.5
	EPI	55.72	56.21	56.65	57.3	57.71	60.28	60.85	62	62.11	61.75	55.18	58.9	61.11
Gabon	NRCA	3.1	3.3	3.5	3.7	3.4	3.3	4	2.9	3.4	4.2	4.4	3.9	3.8
	EPI	43.41	45.42	45.84	45.78	45.95	45.84	45.86	46.24	46.4	46.53	57.91	55.71	46.6
Indonesia	NRCA	3.5	3	2.1	1.7	0.2	0.4	0	-0.2	-0.9	-2.2	-2.8	-2.8	-2.2
	EPI	42.33	42.78	43.32	43.91	43.19	43.22	44.7	44.54	44.42	44.44	52.29	50.7	44.36
Iran	NRCA	27.7	32.5	34.8	46.8	43.1	44.7	50.4	40	42.2	56.5	49.4	27.1	24.5
	EPI	46.85	47.49	48	48.5	49.1	48.4	48.98	49.6	50.76	51.32	42.73	47.8	51.08
Iraq	NRCA	18.6	9.5	18.3	21.1	23.4	26.3	36.1	29.5	31.5	41.9	47.2	44.3	41.7
	EPI	32.61	33.53	33.92	34.19	33.57	33.38	33.28	33.07	33.24	33.42	25.32	30.45	33.39
Kazakhstan	NRCA	7.1	8.4	11.2	14.8	17.2	17.7	23.2	18.7	21.6	26.3	26.5	27.1	25.5
	EPI	49.79	51.46	51.62	50.22	50.31	51.55	52.13	50.73	50.93	50.98	32.94	47.32	51.07
Kuwait	NRCA	20.7	24	27.5	37.8	40.7	39.2	46.7	36.4	37.6	48.6	54.2	53	46.4
	EPI	52	52.13	52.43	52.44	51.47	51.43	50.71	51.09	56.52	64.63	35.54	49.8	63.94

Country	**Index**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Libya	NRCA	41.01	40.76	40.91	41.32	41.7	42	42.3	42.65	42.57	42.53	37.68	40.72	42.72
	EPI	14	17.1	18.8	25.1	28.5	28.4	34.9	26.6	28.8	9.4	30.2	21.9	10
Malaysia	NRCA	-2.8	-2.1	-1.8	-2.4	-3.2	-2.6	-3	-2.9	-3.4	-5	-5.7	-4.9	-3.9
	EPI	57.86	58.89	59.43	60.34	59.34	59.72	60.44	60.62	59.89	59.6	62.51	61.7	59.31
Mexico	NRCA	7.2	10.4	11	12	12.4	12.5	10.7	8	9	10.4	7.2	5.8	2.9
	EPI	50.98	51.5	53.09	52.19	52.66	53.11	53.74	54.17	54.66	54.99	49.11	53.41	55.03
Nigeria	NRCA	37.79	37.81	37.99	36.97	37.02	38.09	38.41	37.33	38.56	38.91	40.14	40.01	39.2
	EPI	25.2	30.3	37.6	44.2	41.8	33.3	41.6	30.9	40.5	44.1	47.9	44.5	37.6
Norway	NRCA	35.4	33.9	35.3	38.1	34.5	31.8	32	25.8	25.1	25.1	22.1	19.8	18.9
	EPI	75.92	76.3	77.33	77.32	77.7	77.76	77.7	77.81	77.97	78.04	69.92	75.8	78.04
Oman	NRCA	10.7	10.2	9.1	11.4	10.6	9.1	11.6	9.7	12	13.1	14.3	14.8	16.6
	EPI	44.04	44.46	44.97	45.74	46.19	45.88	46.47	46.76	47.19	47.66	44	46.22	47.75
Qatar	NRCA	9.9	10.8	11.7	15.2	13.4	14.2	34	20.6	25.1	29.2	28.8	27.2	25.1
	EPI	63.88	64.04	64.53	64.23	63.37	63.31	63.05	63.02	63.27	63.3	46.59	55.9	63.03
Russia	NRCA	34.4	39.6	48.6	59.5	60.7	63.3	68.4	58.7	65.1	70.1	73.5	69.9	62.1
	EPI	51.29	51.37	51.34	51.35	50.84	51.61	52.85	53.22	53.3	53.29	45.43	50.34	53.45
Saudi	NRCA	93	103	113	143	145	135	157	119	129	159	166	157	138
	EPI	64.04	64.68	65.28	66.15	66.92	66.5	66.31	66.36	66.49	66.52	49.97	59.2	66.66
U AE	NRCA	31.4	34.2	36.7	44.8	48.9	43.6	50.3	44.1	38.8	47.2	29.4	29.4	32.1
	EPI	73.61	73.87	73.71	74.05	73.78	72.66	72.5	72.38	72.54	72.89	50.91	65.93	72.91
UK	NRCA	2.5	-0.4	-2.7	-7.4	-8.6	-4.8	-5.4	-2.3	-1.6	-6.7	-5	-7	-3.7
	EPI	74.75	74.64	74.81	75.53	76.31	76.48	76.73	76.88	77.09	77.27	68.82	75.45	77.35
USA	NRCA	-56.9	-53.3	-53.5	-63.9	-67.8	-63.1	-71.8	-57.2	-62	-70.5	-76.5	-69.3	-59.6
	EPI	66.05	66.28	66.07	66.13	66.73	66.57	66.98	67.03	67.53	67.37	56.59	66.21	67.52
Venezuela	NRCA	31.4	27.5	33.6	33.8	35.5	41.5	50.3	40.5	38	44.3	46.8	42.3	35.4
	EPI	57.16	57.67	57.81	57.84	57.97	57.53	57.65	57.77	57.82	57.76	55.62	56.38	57.8