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Estimating the Long-Run Demand Elasticities of Crude Oil: Evidence From GCC Members

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Abstract:

Crude oil has a substantial influence on the world's economies because it impacts people's lives. This study attempts to investigate the crude oil demand response to crude oil prices and income for the Gulf Cooperation Council (GCC) members. To do so, this study applies different techniques such as a unit root test, an ordinary least squares analysis, and Granger causality tests using time series data from 1970 to 2017 to determine the price and income elasticities of crude oil.

The time series data provides information on the prices and consumption of crude oil, which allowed us to identify trends in the long-run demand for crude oil as a commodity. We provide evidence regarding the income and price elasticities of demand for GCC members. The results indicate that the long-run price elasticities for the various GCC members ranged from -1.19 (UAE) to -0.19 (Bahrain). The results also show that the GCC members differ in how crude oil demand responds to income, ranging from 1.26 (the UAE) to 0.10 (Bahrain), which is consistent with economic theory. This research is important because it explicitly considers the impact of price and income changes on oil consumption behaviors, which directly impacts GCC members in the long-run.

Keywords: Long-run demand, crude oil, price elasticity, income elasticity.

JEL Classification: Q41, Q43, D22, D12

1. Introduction

In May 1981, Saudi Arabia, Kuwait, the United Arab Emirates (UAE), Oman, Qatar, and Bahrain established the Gulf Cooperation Council (GCC) to coordinate their military and economic policies. The most important economic feature common to all six members is that they are rich in oil reserves. In addition, each country's gross domestic product (GDP) and economy is largely dependent on exporting oil at competitive prices to other countries (GCC-STAT, 2017). Furthermore, Saudi Arabia, Kuwait, Qatar, and the UAE are full members of the Organization of the Petroleum Exporting Countries (OPEC). Crude oil (the raw material from which petroleum products) are made and natural gas play important roles in both the GCC and economies across the world. Many aspects of human lives are directly or indirectly related to energy, especially crude oil and natural gas. However, the consumption of crude oil in the GCC has increased dramatically over the last 50 years. Importantly, fluctuating oil prices have an enormous impact on a country's economic growth (Bayraktar et al., 2016).

While there are several types of energy such as crude oil, natural gas, coal, electricity, solar, etc., crude oil has dominated the commercial energy market since the decline of coal. Several studies have asserted that crude oil will remain the dominant source of energy throughout the 21st century. Rahman (2004) reported that oil and natural gas will comprise 36.9% and 29.9% of the market, respectively. The majority of demand for crude oil and petroleum products is met through imports from the Gulf countries, with Saudi Arabia leading in imports. Economically, the consumption of crude oil and its products differs by country based on GDP, per capita GDP, industrial structure, lifestyle, geographical location, and energy prices. In regard to manufacturing, the industry defines oil or crude oil as a mineral oil that has not been refined or treated (i.e., in its natural state). The oil industry's operations affect lives across the globe and likely determine certain countries' future trajectories. Taghizadeh-hesary and Yoshino (2014) considered that crude oil greatly influences the world economy because it is a "flow good," as compared to other goods.

The purpose of the present study is to provide empirical evidence of the prices and income elasticities of oil demand in the GCC. To address growing concerns about crude oil stability in the GCC, it is important to estimate and analyze the long-term trend of crude oil consumption.

2. Background

The key to identifying this trend is understanding the nature of the crude oil consumption growth rates. First, it is necessary to examine the history of the oil market and to explore how it has influenced the economies of the GCC members. Oil markets have experienced numerous crises and large shocks over the past 50 years, such as the low oil supply in the 1970s, the oil surplus in the 1980s, the East Asian financial crisis in 1998, positive demand shocks in the 2000s due to growth, and the collapse of prices in mid-2014 due to severe weather.

Theoretically, crude oil prices behave similarly to other commodities that have wide price fluctuations in times of shortages or oversupplies. Any product's price is determined by the law of supply and demand. For crude oil, its price is determined by the supply and demand conditions in the overall global market. According to economic theory, resources that are in scarce supply tend to have high prices. Countries that consume oil need it more than the countries that produce it. This is clearly reflected in the consumption levels of the non-producing countries, which are by far higher than those in the producing countries. Understanding how energy demand responds to prices changes is crucial for policymakers around the world. These responses can be translated into a quantitative elasticities measurement. While numerous empirical studies have analyzed this topic, there is variability in the quality of the results, leading to an inability to compare results across countries. The existing literature generally accepts that oil prices and incomes are likely to be inelastic due to the necessity of oil and the lack of oil alternatives.

The present study's main goal is to compare changes in crude oil consumption behaviors to changes in income and prices for GCC members in terms of long-run income and price elasticities of demand. The paper is structured as follows: section 3 briefly reviews the literature, section 4 presents the methodology and describes the datasets, section 5 provides the main results, and section 6 concludes the paper with a brief discussion of the key findings.

3. Literature Review

In this section, we review the theories and empirical evidence on price and income elasticities related to energy service and crude oil consumption. Significantly, energy plays a crucial role in the modern global economy, with oil and natural gas being the largest energy source (Trench & Miesner, 2006). The majority of the existing literature has focused

on industrialized countries. Dahl and Sterner (1991) reviewed 97 studies (published until 1988) on petroleum energy demand. These studies relied on a variety of methods and used real price and income as explanatory variables. Because these studies used a wide variety of models, Dahl and Sterner categorized the models into ten "distinct groups" based on the uniqueness of their results. They argued that gasoline demand is mostly inelastic to price and income. Moreover, they asserted that correlating the first and second models (of the ten distinct model groups).

Sene (2012) and Akinboade et al. (2008) focused on a few developing countries and find different results. Hazarika (2016) indicated that the leading oil producing countries, such as Saudi Arabia, the UAE, Kuwait, Azerbaijan, Russia, and Kazakhstan, are mostly dependent on fuel for economic growth. Pesaran et al. (2001) found that most oil demand research uses time series analyses, while only few studies relied on panel data models. There are several studies that have used time series analyses to investigate either an individual country or a group of countries; a number of these studies applied an autoregressive distributed lag (ARDL) bounds testing approach to cointegration.

3.1 Energy Demand

According to Deaton and Muellbauer (1980), consumer theory asserts that individuals and households consume goods and services in order to maximize their utility, which is dependent on their budget constraints and the current prices of goods and services. Al-Faris (1997) concluded that the research on energy demand is mostly concerned with how to measure the speed and degree of consumer responses to changes in income and fuel prices. In addition, such research focuses on recommending policies that aim to protect the environment. Fournier et al. (2013) found that the demand for oil increased between 2000 and 2010 in non-OECD countries by 14% but sharply decreased in OECD countries.

Deaton and Muellbauer (1980) found that the energy demand, following a reduction in price, may increase more than a normal amount, increase the normal amount, or even decrease. In reality, the demand for energy is determined by a desire for energy services, such as water heating/cooling, transportation, lighting, powering appliances, etc. (Goldemberg et al., 1985). Bayat et al. (2017) examined whether or not energy consumption is an important factor for economic growth in Brazil, Russia, India, China, and South Africa (the [BRICS] countries). These authors conducted a panel data analysis for the period 1990 to 2013 and found support for the conservation hypothesis in Russia, the feedback

hypothesis in Brazil, and the neutrality hypothesis in the remaining countries. Similarly, Sama and Tah (2016) explored the impact of energy consumption on economic growth in Cameroon. They used secondary time series data and the generalized moment technique method and found that GDP, population growth rate, and petroleum prices are positively related to petroleum consumption. They also empirically established that there is a positive relationship between the rate of inflation and economic growth.

Yanagisawa (2012) clarified that the purchasing power of a country that imports oil significantly declines when oil prices increase, leading to a multiplier effect that impacts both consumers and producers. Nordhaus (1996) and Fouquet (2011) found that, due to efficiency improvements, the cost of consuming one unit of energy service has more quickly decreased in the long run in comparison to the price of energy. These authors assert that the availability of long-term datasets (dating back hundreds of years) has allowed economists to determine the growth of the main economic variables, including those relevant for energy markets.

3.2. Energy and Oil Elasticities of Demand

Theoretically, the oil price elasticity of demand measures the percentage change in oil consumption against a percentage change in income or oil price. In other words, the price elasticities of demand can be used to measure the responsiveness of consumers to changes in the price of consumed crude oil or average income. However, there have only been a few attempts to use specific long-term data to identify trends in energy demand elasticities (Fouquet & Pearson, 2012; Fouquet, 2012). Several early economic studies noted that demand varies and that an elasticity estimate should be an average over a number of years or consumers (Working, 1925; Stigler, 1954). Additionally, Pindyck (1979) estimated the long-term price elasticity for crude oil in the OECD countries in the industrial sector. He found that price elasticity decreased from 0.22 to -1.17.

In the context of energy demand, several studies (e.g., Hsing, 1990; Goodwin et al., 2004; Hughes et al., 2008) have tried to identify changes in elasticities. However, numerous studies have produced single estimates (often assuming constant elasticities) due to a lack of data availability and the need to find statistically significant results in econometric analyses (e.g., Marquez, 1994). Importantly, Al-Faris (1997), Lee and Lee (2010), and Al-Yousef (2013) emphasized that accurate information about income and price elasticities provides

policymakers with a guide for the levels to which oil prices should be increased to reduce domestic consumption, and they identified that the market has the potential to understand energy conservation. From an environmental prospect, Iwayemi et al. (2010) estimated the price and income elasticities of oil demand as a crucial element for implementing policies that are concerned with the negative environmental externalities of the energy sector and for applying more informed and successful energy policies.

Eltony and Al-Mutairi (1995) argued that demand for gasoline is price and income inelastic in Kuwait, as a country that develops and produces oil. In their empirical study, Akinboade et al. (2008) used an ARDL model to estimate the price and income elasticity of demand for gasoline in South Africa. They found that gasoline demand is inelastic in certain South African countries. Fouquet and Pearson (2012) argued that, hypothetically, concentrating only on energy demand and ignoring efficiency improvements assumes that the price elasticity of demand for energy services is equal to unity. Narayan and Smyth (2007) estimated demand elasticities for oil in 12 Middle Eastern countries for the period 1971– 2002. They estimated that the long-run income and price elasticities ranged from 0.727 to 1.816 and –0.002 to –0.071, respectively. However, they found that the short-run income and price elasticities also ranged from 0.171 and –0.0008 (this estimate was not significant), respectively.

Dahl (2012) classified the price of gasoline demand and found that the most frequent elasticity estimates imply that gasoline demand is mainly price inelastic. Moreover, Narayan and Wong (2009) examined the determinants of oil consumption for a panel consisting of one Australian territory and six states for the period 1985–2006. Surprisingly, they found that long-run income elasticity was 0.17, while long-run price elasticity was 0.02 (this estimate was not significant). Using yearly data, Cooper (2003) estimated a log-linear equation by including oil consumption as a function of crude oil price and GDP per capita to measure short- and long-run price elasticities. He found that the long-run price elasticities for the Group of Seven (G7) countries ranged from 0.18 to -0.45, which is close to the bounds estimated by the US Federal Energy Office (-0.2 to -0.6). Using a linear supply and demand model, Krichene (2002) estimated crude oil demand and supply elasticities with yearly data for the period 1918-1999. Krichene found that the long-run price elasticity of demand, which he estimated with a co-integration approach and an error correction method, was also low (-0.05 in 1918-1999, -0.13 in 1918-1973, and nearly zero in 1973-1999).

Pesaran et al. (1998) estimated the long-run price elasticities for a group of Asian countries. These authors reported that the price elasticity for energy demand was -0.33 in the aggregate, -0.52 for industrial, 0.36 for transportation, -0.47 for residential, and -0.08 for commercial. Using time series data to examine the forms of price and income elasticity for energy demand, Phoumin and Kimura (2014) measured the elasticity of energy prices in East Asian countries. They implemented a dynamic log-linear energy demand model, using country-based data for both short- and long-run price and income elasticities. They found that prices were generally inelastic for nearly all countries included in the study. Ghosh (2007) reported that price demand is inelastic in the long-run; specifically, the long-run price elasticity of demand is -0.63 (this estimate was not statistically significant).

Moreover, Xiong and Wu (2009) examined and forecasted crude oil demand in China for the time period spanning 1979-2004. They estimated that income elasticity is 0.647 and that price elasticity is -0.365. Similarly, Gately and Huntington (2001) investigated the determinants of oil demand for OECD and non-OECD countries, and they determined the long-run income and price elasticities of oil demand in OECD countries to be 0.56 and -0.64, respectively. Espey and Espey (2004) reported lower price elasticities for electricity demand in the short-term (-0.21 versus -0.35) and long-term (-0.61 versus -0.85) in comparison to other meta-analyses. Hesse and Tarkka (1986) studied energy demand in the European manufacturing industry between 1960-1980, and they estimated price elasticity to be -0.35. Table 1 summarizes the existing research, as we are unable to provide complete details on the methods and results of all oil demand studies. Table 1 illustrates that the results vary across studies due to differences in estimation methods, type of data (time series or cross-sectional), and model specifications.

Table 1. Reported values for the elasticity of oil demand

Study	SR-price elasticity (β_1)	LR-price Elasticity (β_1)	LR-income Elasticity (β_2)
Altinay (2007)	-0.10	-0.18	0.64
Cooper (2003)	-0.05	-0.568	0.023
Dahl (1993)	-0.07	-1.60	N/A
Hughes et al. (2008)	-0.04	- 0.34	0.54

Krichene (2002)	-0.06	-0.13	0.60
Pindyck (1979)	N/A	-1.17	N/A
Pesaran et al. (1998)	-0.143	-0.52	0.066
Ghosh (2007)	N/A	-0.63	1.97
Ziramba (2010)	- 0.046	-0.147	0.43
Xiong and Wu (2009)	N/A	-0.365	0.65
Gately and Huntington (2001)	-0.05	-0.64	0.56
Hesse and Tarkka (1986)	N/A	-0.35	0.31
Narayan and Smyth (2007)	–0.0008	–0.071	1.816
Narayan and Wong (2009)	N/A	0.02	0.17
Average	-0.06988	-0.50923	0.647917

Source: Prepared by researcher from reviewing previous studies from 1979 to 2010

The results presented in Table 1 provide evidence that income elasticity (on average) is positive inelastic ($0< \beta_2 <1$), and that both short- and long-run price elasticities are mostly negative inelastic ($0< |\beta_1| <1$). Narayan and Wong (2009) notably found a different result for long-run price elasticity.

However, the results presented in Table 1 indicate that the short-run price elasticities are always smaller than the long-run price elasticities, which is consistent with economic theories.

4. Methodology

4.1. Hypotheses:

Based on the above discussion, we developed the following hypotheses:

H_{1o}: There is no negatively significant relationship between crude oil prices and crude oil consumption in the GCC (null hypothesis).

H_{11}: There is a negatively significant relationship between crude oil prices and crude oil consumption in the GCC (alternative hypothesis).

H_{2o}: There is no positively significant relationship between per capita income (GDP) and crude oil consumption in the GCC (null hypothesis).

H_{21}: There is a positively significant relationship between per capita income (GDP) and crude oil consumption in the GCC (alternative hypothesis).

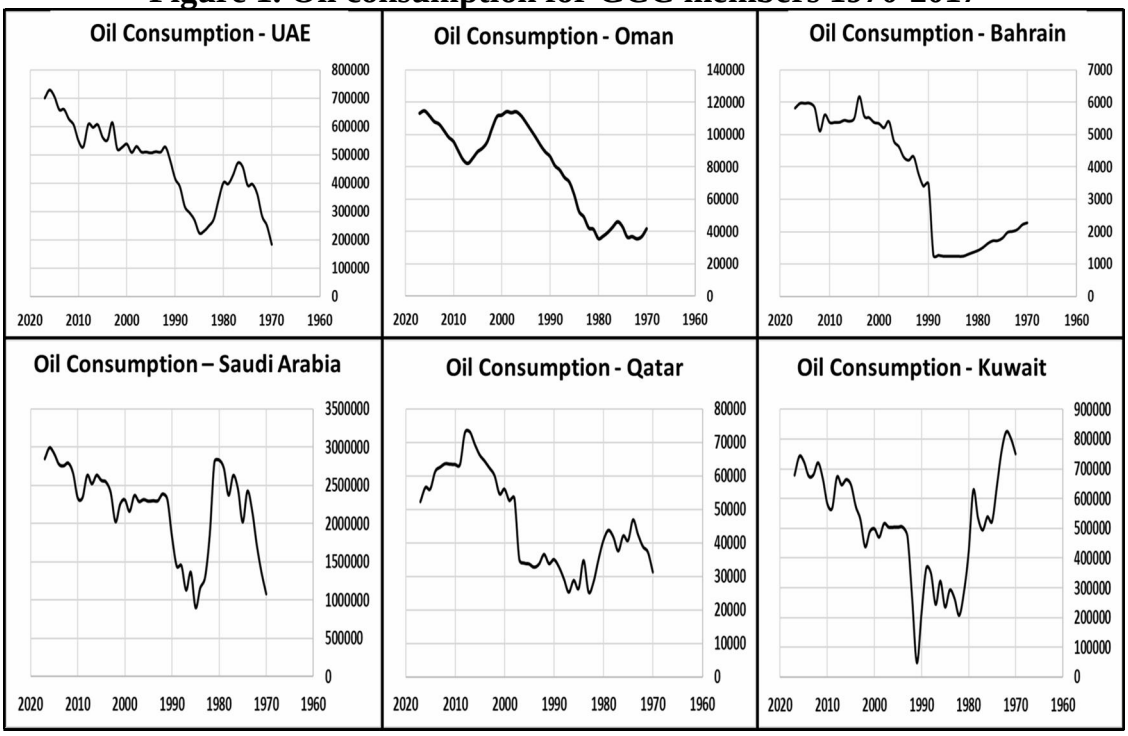
We will only reject the null hypotheses if there is sufficient evidence to support that the null is not true. The alternative hypothesis $\boldsymbol{H_0}$ will be accepted if the null hypothesis is rejected. $\boldsymbol{H_1}$ must contain all the possible outcomes that are not included in $\boldsymbol{H_0}$.

4.2 Data

Secondary GCC data sources were used to conduct the analysis and inspect the crude oil consumption of GCC members. Specifically, the analysis used time series data spanning 48 years, covering the period 1970 to 2017. The World Bank Indicators (WBI) and OPEC data were used to compile the data for this study. This combination of variables obtained from these two datasets allowed us to formulate a time series for GCC members.

It appears that the WBI is the most consistently reliable data source for oil consumption, as it provides complete and detailed time series from 1960 to 2017 for most countries around the world. We used the WBI's (2017) data on crude oil consumption and divided it by the population size to obtain an estimate for per capita oil consumption. As a substitution for income level, we used the WBI's (2017) data on per capita real GDP in constant 2010 US dollars. Figure 1 shows the daily oil consumption by GCC members for the period 1970 to 2017.

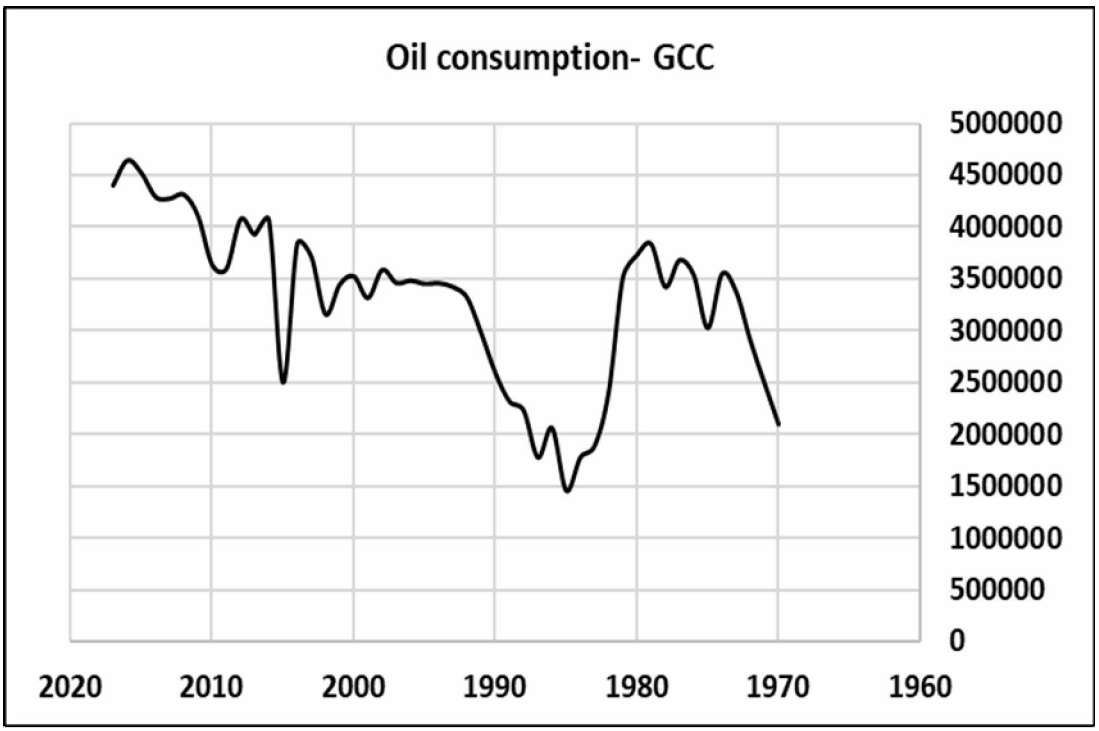
Figure 1. Oil consumption for GCC members 1970-2017



Source: World Bank Indicator (2017). World Development Indicators. Accessed Feb 2017. www.data.worldbank.org.

Figure 1 illustrates that all members experienced an increase in oil consumption in the two decades following the mid-1990s. Figure 2 shows that, in general, the aggregate oil consumption of all members followed the same trend. As indicated by Narayan and Smyth (2007), real per capita income models structural change. In addition, we defined real oil prices based on oil prices in US dollars, and these prices have not been converted to any domestic currencies. Figure 2 illustrates the GCC members' consumption behaviors (in general) from 1970 to 2017, which reflects how prices and production fluctuated over the 48-year-period.

Figure 2. The aggregate level of oil consumption for GCC members 1970-2017



Source: World Bank Indicator (2017). World Development Indicators. Accessed Feb 2017. www.data.worldbank.org.

4.3. Model

To investigate the price and income elasticities, this study assumes that demand is a function of price and income and holds other factors constant. This is a common practice in the existing literature. Additionally, standard economic theory suggests that consumers react to price changes to certain goods by adjusting their demand for those goods. As prices increase, consumers reduce the quantity demanded. As prices decrease, consumers increase the quantity demanded. Customers' responsiveness to price changes is referred to as their price elasticity of demand. This relationship is represented in the following equations:

Piece Elasticity of Demand:

$$ePoil = \frac{\frac{\Delta Qoil}{Qoil}}{\frac{\Delta Poil}{Poil}} = \frac{\Delta Qoil}{\Delta Poil} X \frac{Poil}{Qoil} \quad (1)$$

Income Elasticity of Demand:

$$eIoil = \frac{\frac{\Delta Qoil}{Qoil}}{\frac{\Delta Ioil}{Ioil}} = \frac{\Delta Qoil}{\Delta Ioil} X \frac{Ioil}{Qoil} \quad (2)$$

As shown in equations (1) and (2), the price elasticities of demand can be measured as a customer's sensitivity or responsiveness to changes in the price of crude oil consumed or their average income. Based on the Marshallian theory of demand for goods and services and following Altinay (2007), Narayan and Smyth (2007), Narayan and Wong (2009), and Lee and Lee (2010), this study uses a log-linear specification that is widely used in energy demand modeling. This approach provides stronger and more reliable results than a simple linear specification.

This study uses the ordinary least square (OLS) regression method and additional econometrics techniques such as a unit root test (to make sure the series is stationary) and a Granger causality test to analyze how the independent variables impact the dependent variable. According to Pohlmann and Leitner (2003), OLS is a statistical technique that can be used to determine the relationship between explanatory variables and a dependent, including an error or disturbance term. The error term and linear combination of the independent variables explain the dependent variable. An important feature of OLS is that it minimizes the sum of the squared disturbances or errors for all variables when calculating the parameter values (Campbell & Campbell, 2008).

The specific model used in this study is based on existing research, including Cooper (2003), Phoumin and Kimura (2014), Altinay (2007), Ziramba (2010). The model's basic form is provided in equation (3):

$$D_t = f(Y_t, P_t) \quad (3)$$

Where D_t represents crude oil consumption (as GCC crude oil demand), *Yt* is equal to the growth rate in income, and *Pt* represents the price of crude oil (in US dollars). Equation (4) presents the model:

$$D_{oilt} = \alpha - \beta_1 P_{oilt} + \beta_2 Y_t + \mathcal{E}_t \quad (4)$$

Where α represents the constant term, β_1 and β_2 are the coefficients for the independent variables (income and crude oil price growth rates), and ε_t represents the model's disturbance term. We expect that β_1 will be negative and that β_2 will be positive. To increase the model's specifications, we applied a natural logarithmic to all data prior to conducting the analysis and defined the model as follows:

$$Lag\ (D_{oilt}) = \alpha - \beta_1\ Lag\ (P_{oilt}) + \beta_2\ Lag\ (Y_t) + \varepsilon_t \qquad (5)$$

Based on demand theory, we generally expect the sign of β_1 to be negative based on the expectation that a higher per capita income level leads to an increase in oil consumption. However, Farinelli et al. (2009) indicated that if oil is considered to be an inferior good and not a normal one, β_2 may also be negative since increases in income level may direct some developed OECD countries to use alternative and eco-friendly sources

5. Results and Discussion

We applied different techniques for the long-run estimation. While it is possible to vary the software used in the econometric estimation of variables, we used EViews 9.0 for all estimations. Regarding the data, our analysis was built based on the estimation used in Cooper's (2003) seminal paper. Our log-linear equation included oil consumption as a function of crude oil price and income (GDP per capita) to measure long-run price elasticities.

The first step in the econometric analysis was to examine the time series properties of the data and to determine whether or not the series was non-stationary. This is a necessary first step because most variables in time series data are not stationary. To do so, we used a unit root test, which is a more advanced test, and were unable to reject the non-stationarity of GDP per capita, prices, and the consumption of the individual GCC members. Therefore, we applied an ADF test to determine whether the variables were stationary.

Table 2. Unit root test results

Variable	Level (sig)	Stationary	First difference (p-values)	Stationary
KSA	0.6795	NO	0.0000	YES
Y-KSA	0.5278	NO	0.0001	YES
UAE	0.0887	YES*	0.3378	NO
Y-UAE	0.0948	YES*	0.0000	YES
KU	0.2337	NO	0.0546	YES

Y-KU	0.5547	NO	0.0000	YES
QAT	0.3310	NO	0.0000	YES
Y-QAT	0.7534	NO	0.0000	YES
OMN	0.7645	NO	0.0002	YES
Y-OMN	0.7185	NO	0.0000	YES
BAH	0.5257	NO	0.0000	YES
Y-BAH	0.2715	NO	0.0000	YES
GCC	0.6907	NO	0.0000	YES
Y-GCC	0.5520	NO	0.0000	YES
Oil-P	0.5199	NO	0.0000	YES

Source: Prepared by researcher using E-views software version -9

We conducted an AD test to determine whether the variables were stationary; the results indicated that all variables were not stationary at level but were stationary in the first difference (except for UAE consumption). The stationarity analysis showed that most of the variables were stationary in the first difference and that one variable was stationary on level. It was necessary to account for the possibility that the variables were not stationary because this is time series data. Conducting a regression with non-stationary variables on both sides of the equation could produce significant coefficients that are only based on a correlation between the trends rather than a correlation between the underlying variables (Dahl, 1991).

We used a model that estimates the long-run relationship between the variables. This is because the majority of our variables were originally non-stationary but did become stationary after first differencing. We also used this model because long-run oil consumption, GDP per capita, and oil prices are often cointegrated and hence their movements are closely related (Fouquet et al., 1997).

To determine the causal relationships between the variables, we applied the Granger causality test. This test allowed us to identify the causal relationship between crude oil consumption and each explanatory variable (crude oil price and per capita GDP).

Subsequently, this test also examined the opposite direction. The general formula for Granger causality is as follows:

$$X_t = \alpha_1 X_{t-i} + \beta_1 Y_{t-i} + \mu_t \quad (6)$$

$$Y_t = \alpha_2 Y_{t-i} + \beta_2 X_{t-i} + \mu_t \quad (7)$$

Here, α_1 and α_2 represent the coefficients of X and Y, respectively. β_1 and β_2 are the coefficients of Y and X, respectively, while μ_t represents the random vectors. Table 3 shows the results of the granger causality test.

Table 3. Granger causality test results

Pairwise Comparisons	Sig. level	Existence of Direction	Type of Direction
Price causes KSA consumption	0.0495	YES	Unidirectional
KSA consumption causes price	0.2384	NO	
KSA_Y causes KSA consumption	0.0088	YES	Unidirectional
KSA consumption causes KSA_Y	0.6883	NO	
Price causes UAE-consumption	0.0050	YES	Unidirectional
UAE- consumption causes price	0.7868	NO	
UAE_Y causes UAE-consumption	0.0002	YES	Unidirectional
UAE- consumption causes UAE_Y	0.8020	NO	
Price causes KU- consumption	0.1431	NO	No direction
KU- consumption causes price	0.5520	NO	
KU_Y causes KU-consumption	0.0024	YES	Unidirectional
KU- consumption causes KU_Y	0.7413	NO	
Price causes QAT-consumption	0.1111	NO	No direction
QAT- consumption causes price	0.2705	NO	
QAT_Y causes QAT-consumption	0.0016	YES	Unidirectional
QAT- consumption causes QAT_Y	0.6520	NO	
Price causes Oman-consumption	0.3558	NO	No direction
Oman- consumption causes price	0.1346	NO	

Oman-Y causes Oman-consumption	0.0325	YES	Unidirectional
Oman- consumption causes Oman-Y	0.2668	NO	
Price causes BAH-consumption	0.9394	NO	No direction
BAH- consumption causes price	0.2045	NO	
BAH_Y causes BAH-consumption	0.9502	NO	No direction
BAH- consumption causes BAH_Y	0.7960	NO	
Price causes GCC-consumption	0.0178	YES	Unidirectional
GCC- consumption causes price	0.1474	NO	
CC_Y causes GCC-consumption	0.0111	YES	Unidirectional
GCC- consumption causes CC_Y	0.5054	NO	

Source: Prepared by researcher using E-views software version -9

As summarized in Table 3, the crude consumption for three members (Saudi Arabia, UAE, and Qatar) does not Granger cause oil price, but oil price does Granger cause crude oil consumption. This is referred to as a unidirectional causal relationship between oil price and crude oil consumption. On the other hand, there is not a directional causal relationship between oil price and crude oil consumption for the three remaining members (Kuwait, Oman, and Bahrain).

Table 3 also illustrates that the per capita income for most members (Saudi Arabia, UAE, Kuwait, Bahrain, and Qatar) does not Granger cause oil consumption, but oil consumption does Granger cause per capita income (GDP). This indicates that there is a unidirectional causal relationship between oil consumption and per capita income (GDP) for these members. However, for Oman, there is not a directional causal relationship between oil consumption and per capita income (GDP). Generally, there were unidirectional causal relationships in the GCC for both relationships.

Table 4. Regression analysis results

Dependent Variables	*Description*	*Coefficient*	*SIG*	*S.E*	R^2
KSA	*constant*	*-5.559976*	*0.0000*	0.342289	0.527401
	Oil price	*-0.900601*	*0.0000*		
	KSA-Y	*0.706536*	*0.0003*		
UAE	*constant*	*-10.70577*	*0.0018*	0.342180	0.821677
	Oil price	*-1.193742*	*0.0000*		
	UAE-Y	*1.260172*	*0.0007*		
KU	*constant*	*1.116599*	*0.1824*	0.226828	0.724220
	Oil price	*-0.448219*	*0.0000*		
	KU-Y	*0.042046*	*0.7037*		
QAT	*constant*	*0.273878*	*0.9174*	0.722673	0.719821
	Oil price	*-1.103400*	*0.0003*		
	QAT-Y	*-0.297283*	*0.4001*		
OMN	*constant*	*-3.504798*	*0.0000*	0.138074	0.650288
	Oil price	*-0.402687*	*0.0000*		
	OMN-Y	*0.181710*	*0.0037*		
BAH	*constant*	*-3.457277*	*0.0007*	0.387375	0.062762
	Oil price	*-0.190483*	*0.1733*		
	BAH-Y	*0.102456*	*0.4783*		
GCC	*constant*	*-6.434492*	*0.0022*	0.323133	0.596500
	Oil price	*-0.926359*	*0.0000*		
	GCC-Y	*0.768031*	*0.0051*		

Source: Prepared by researcher using E-views software version -9

Table 4 presents the results from the regression analysis. Our results are mostly consistent with the empirical research that tends to yield low values for long-term demand price elasticities. Our results are quite similar to the existing empirical research regarding income elasticity, which is generally close to or higher than unity in the long run for all members. Table 3 presents the results from the basic model Equation (4) and the model with additional specifications. The coefficient estimated for the long-run price elasticity in the GCC is statistically significant and equals -0.93.

The coefficient for oil price is negative and significant, indicating that demand for oil decreases as oil price variance increases. Regarding the sign of $\beta 1$, we expected it to be negative, as price is inversely related to quantity demanded.

Table 5. Summary of results (coefficients [β])

Variable	$\beta 1$ Value	$\beta 2$ Value
GCC	*– 0.926359*	*0.768031*
KSA	*– 0.9000601*	*0.706536*
UAE	*– 1.193742*	*1.2601712*

KU	*– 0.448219*	*0.042046*
QAT	*– 1.103400*	*- 0.297283*
OMN	*– 0.402687*	*0.181710*
BAH	*– 0.190483*	*0.102456*

Table 5 presents the results for the GCC as a whole and for each GCC member individually. As discussed previously, the price and income elasticities of demand for oil measure the responsiveness or sensitivity of oil demand to changes in price and income levels. As expected, the coefficients for long-run price elasticities for the GCC members are significant and negative. An increase in oil price decreases oil consumption per capita levels for all six countries. In addition, the price is assumed to be inelastic if the degree of crude oil demand sensitivity to price is low, whereas price is assumed to be elastic if changes in price and income lead to significant responses in oil demand.

With respect to the individual country results, for UAE and Qatar, the long-run price elasticities are elastic (-1.19 and -1.1, respectively). The coefficients for these price elasticity variables were negative and significant. The long-run price elasticities for the GCC in the aggregate (-0.93) and for KSA (-0.90) individually are very similar. The long-run price elasticities for the remaining GCC members (Kuwait, Oman, and Bahrain) behave differently and are all inelastic (-0.45, -0.40, and -0.19, respectively). These estimates are close to the existing literature's reported range of estimated elasticity values displayed in Table 1.

However, Oil crud correspondences to per capita income (GDP) are differed among members. Table 5 shows this and illustrates that income elasticities are positive for the GCC in the aggregate and for KSA, the UAE, Kuwait, Oman, and Bahrain individually (0.77, 0.71, 1.26, 0.042, 0.18, and 0.10, respectively). This is consistent with economic theory as it applies to normal and luxury goods. We obtained an unexpected result for Qatar—a significant and negative income elasticity coefficient (-0.30)— which indicates that crude oil in Qatar is classified as an inferior good (based on economic theory). Remarkably, income elasticity in the UAE is elastic (1.26) but is inelastic for KSA, Kuwait, Qatar, Oman, and Bahrain, and GCC in aggregate. For the most part, the price and income elasticities align with economic theory. The results suggest that a 1% increase in GDP per capita

corresponds to a 0.77% increase in oil consumption for the GCC members. On the other hand, a 1% increase in oil price decreases oil demand by 0.93% in the long run.

The existing research indicates that oil demand, in the long-run, is both income and price inelastic (Altinay, 2007; Narayan & Smyth, 2007; Narayan & Wong, 2009). We found that KSA, the UAE, Kuwait, Qatar, Oman, and Bahrain are more price sensitive in comparison to other developing and developed countries. In regard to income elasticity, we found that income is sensitive to oil consumption (except for Qatar, where crude oil is considered to be an inferior good). In theory, price signals have played a central role in adjusting supply and demand. However, oil as a commodity has been highly regulated and thus price signals may not be functioning as intended. The sensitivity to price helps reduce oil demand in reality. Our findings clearly highlight the effect of oil subsidies on oil prices, as any increase in price helps to reduce oil consumption by less than unity.

6. Conclusion

This study attempted to provide the elasticities of crude oil demand in the GCC using annual data for the period 1970 to 2017. We used a dynamic model by introducing a lagged dependent variable as an explanatory variable. We conducted a unit root test to determine whether the time series was stationary and, subsequently, all data was made stationary by first differencing. Further, we examined the causality between the variables of interest and confirmed that causality is unidirectional in the GCC and runs from price to oil consumption, supporting the unidirectional hypothesis. We also established that there is unidirectional causal relationship from income to oil consumption in the GCC. However, the individual GCC members differed in terms of the direction of causality.

We conducted a co-integration analysis to explore to the long-term relationships between variables because the majority of variables were not stationary at level. The results suggested that there are long-run relationships between the variables (i.e., that all variables may affect each other in the long run).

We present evidence regarding the trends of income and price elasticities of crude oil demand in the GCC. The results generally show that price and income (on average) are inelastic in the long run, while price is elastic in the UAE and Qatar. The results also indicate that income is positively inelastic in all GCC members except Qatar. However, the degree of sensitivity to price elasticity varies by country depending on the country's economic structure. With respect to the individual countries, for the UAE (-1.19) and Qatar (-1.1), the long-run price elasticities are elastic. In addition, the estimates for the GCC in the

aggregate (-0.93) and KSA (-0.9) individually are very similar. However, the long-run price elasticity estimates for Kuwait, Oman, and Bahrain are inelastic and ranged from -0.45 to -0.19.

Additionally, this study showed that crude oil responses to income differs across GCC members (ranging from 1.26 to 0.10), which is consistent with economic theory in regard to normal and luxury goods. However, an unexpected result was obtained for Qatar (a significant negative income elasticity coefficient [-0.30]), indicating that crude oil is domestically classified as an inferior good in Qatar (based on economics theory). Numerous studies have identified that, in the long-run, crude oil demand is both income and price inelastic for the majority of cases (Altinay, 2007; Narayan & Smyth, 2007; Narayan & Wong, 2009). Our results indicate that KSA, the UAE, Kuwait, Qatar, Oman, and Bahrain are price sensitive compared to other developing and developed countries. In this study, we analyzed how price and income impact crude oil demand across the GCC. We hope that policies can be implemented that help these economies to obtain economic and non-economic benefits because an increase in oil demand affects income.

7. References.

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