Energy Demand Interplay with Real GDP and Oil Prices

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Abstract

Crude oil has become a prominent indicator for economic activities worldwide, due to its outstanding importance in the supply of the world's energy demands. Many economists believe that there is a strong relationship between the growth rate of a country and oil-prices. As such we attempt to investigate the determinants of aggregate energy demand in **two economies** based on both real energy price and real gross domestic product (RGDP). The data used in this study covers that of Organization for Economic Co-operation and Development (OECD) and Organization of the Petroleum Exporting Countries (OPEC) member countries. Intense findings of this empirical study are that in long-run oil-prices and Real GDP have significant impacts on energy demand for the OECD's. While for the OPEC region a moderate impact was found. The short-run result for both OPEC and OECD corresponds to what Keynesian vein assumes "prices are rigid in a short-run".

JEL classification numbers: Q41, Q42, Q43
Keywords: Oil price, Real Gross domestic product, Energy demand, OPEC, OECD.

1 Introduction

During the last few decades the discovery of new crude oil in some part of the world has made the global economy to be more sufficient in terms of energy productivity; virtually most economic activities depend on crude oil as source of energy. The purpose of this paper is to investigate if energy demand is negatively or positively affected by the increase of real gross domestic product (RGDP) and changes in oil price. We focused on the economies of two regions OECD member countries and OPEC. Although some OECD member countries produce crude oil, the fact still remains OPEC member countries are oil exporters while OECD are importers. Perhaps security of demand is just as important to producers, as security of supply is to consumers, because economic situations are uncertain (OPEC-B, 2012).

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2 Theoretical Background

The global dependence on crude oil as source of energy has triggered economists to channel their research towards the relationship between oil prices and economic growth. A large volume of literature exists on this subject. However, whether oil-price and real GDP determines energy demand is not clear. Rotemberg and Woodford (1996) argued that oil-prices have impact on real economic activities including supply and demand channels. Analyzing their views through a pragmatic window, demand is negatively affected by oil-price changes because the level of consumption drops and consumption is affected indirectly through its positive relationship with disposable income. On the other hand supply is negatively affected due to the fact that firms need energy for their daily productivity. Thus, increase in oil-price will lead to a rise in production costs which in turn lower firms output. Their findings were interesting, but failed to specify the effect of RGDP on energy demand which provide a space for extra studies. Our model is based on short-run as well as long–run.

One important phenomenon we consider is that energy demand for daily activities is crucial; therefore the short-run period for energy and other goods and services may vary. Bruno and Sachs (1982) concluded that inflation indirectly affects oil prices and the result has fatal macroeconomic consequences. Jiménez-Rodríguez and Sánchez (2004) noted that there is a "significant relationship between oil prices and macroeconomic variables in some of the OECD countries, except Japan". Nevertheless, the effects of fluctuation in oil-prices have distinct effects on demand in different countries. The effects have great impact on unemployment especially in capital and energy intensive industries (Davis-Haltiwanger, 2001). Further, unemployment leads to dependence on government support. This affects demand and output in the OECD countries which automatically reflect on their RGDP. For example (IEA, 2012) reported that oil energy demand fell in the last quarter of 2012 due to persistent weakness in Europe OECD countries and impact of Hurricane Sandy in the US as well as the U.S. 'fiscal cliff' if implemented may lead to deeper recession. However, fall in oil-price is expected to continue because most OECD countries will not experience growth due to high budget deficit of their members popularly known as the "**pigs**" (Portugal, Italy, Greece, and Spain). Non-OPEC crude oil production is expected to grow as a result of new discoveries of crude oil and alternative energy sources around the globe. Hence an increase in the competitiveness of the energy market should be expected but demand is expected to grow by more than 50% towards 2035 (OPEC-B, 2012)

3 The Impact of Oil Prices on Economic Growth (OPEC and OECD)

The global economic growth increase the demand for crude oil energy, this high demand drives up the price and vice versa especially during recessions. Increase in oil-price and fear of recession in 1997 lead to slight and abnormal increase in energy demand of the OECD region and slow economic growth, additionally the crisis between 1999-2003, as well as high oil-prices resulted to static demand for the OECD's. Another amazing factor was the fall in demand for the oil producers OPEC. All the trends did not affect the OECD RGDP as it continues to grow steadily as it was expected to do.

However, in 2008 demand for energy in the OECD declines from 49.3 m/b to 47.6 m/b because price of oil was at its peak around $99.6 per barrel. In 2009 the RGDP of OECD declined as a result of economic crisis; supply and demand gap in the energy intensive industries mostly located within the OECD regions. On the other hand the OPEC economy seems to be moving steady, not until 2009 when the RGDP declines due to lack of demand from their trading partners in the OECD regions. The same trends occurred in year 2011 for the OPEC region, there RGDP continue to decline as result of alternative energy source and new oil discoveries in the OECD region due to high oil-prices from the previous year (see table 1)
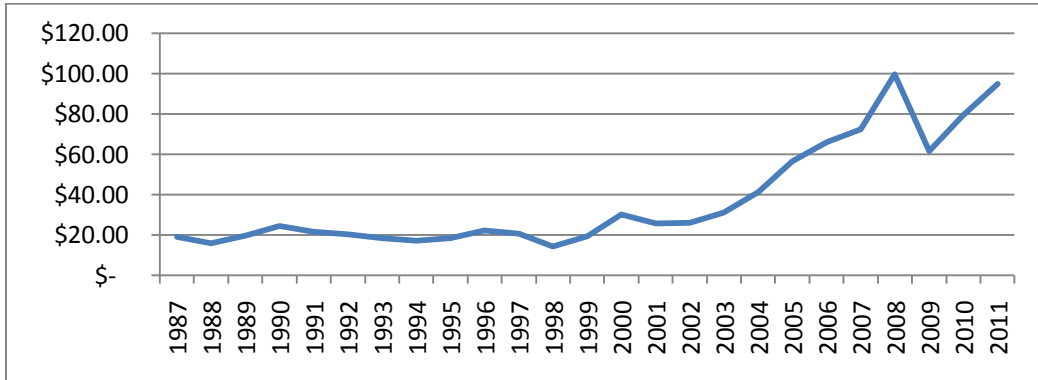

Figure 1: Global oil price over 25 years period.

Ghalayini, L. (2011) argued that growth in economic activities and GDP will definitely lead to increase in energy demand, suggesting that high prices will cut energy demand and thus, reduce economic growth. The author also stated that price elasticity for energy is always thought to be negative but that's not true; for OPEC members it should be considered positive and negative for the OECD's and the reverse is expected for price fall. The extant literature shows that increase in oil-price lead to a transfer of income from OECD to OPEC countries through a shift in the terms of trade. The OECD demand impact would depend on how much of the extra revenue accruing to OPEC is re-spent; typically such revenues are not fully re-spent in the short term; the consequences might be increased in public dept of OECD countries (subsidies) or (tax increase) and on the other hand demand may fall. Nevertheless OPEC countries may spend some or all of their extra revenues on OECD goods and services, but the types of goods and services they buy will differ from those that OECD consumers would buy. Hence the economic balance will depend on how quickly and how much domestic and OPEC consumers spend on OECD goods and services. Energy is the most important aspect of production, if the cost is high then the cost of inputs increases. If the cost increase cannot be passed onto consumers, economic inputs such as labor and capital stock may be reallocated. Increase in the cost of energy destabilizes the economy through losses as a result of costs of changing "menu" prices and cost of switching is almost inevitable in a short-run.

OPEC (2012) pointed out that "it is commonly believed that the world's oil-producing countries —"OPEC Member Countries" — earn huge revenues from the sale of their oil to the rest of the world. But that is another myth. While revenues are indeed generated, they are earned primarily by the governments of most oil consuming countries, not OPEC. OECD nations for example, earn far more revenues from taxes on the sale of imported and refined oil than OPEC member countries make from the original sale of

their oil". Secondly, looking at employment rate and other economic hardships in OPEC countries it's obviously not at full potential in contrast with OECD nations.

4 Methodology

The study employed a demand function of energy by using the following theory:

$Y_t = f(P_E, RGDP)$

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$Y_t = (P_E, RGDP)$ where Y_t stands for aggregate energy demand, P_E Stands for energy real price and **RGDP** stands for real GDP of the related region. The origins of our datas include OPEC library, OECD statistical library and International energy agency, as well as forecast chart website. Table 1 depicts the data used in this study and the analysis was done using microfit software. In this study, Ordinary-Least-Square (OLS) was conducted to empirically investigate determinants of aggregate energy demand.

Table 1: Research data (Comparing OPEC and OECD)

Year	Avg Oil Price (b)	OPEC Demand(mb)	OPEC RGDP (m$)	OECD Demand(mb)	OECD RGDP(m $)
1987	19.2	3.21	553582	36.0	13888669
1988	15.9	3.34	558979	37.2	15025593
1989	19.6	3.42	569495	37.6	16187823
1990	24.5	3.59	602599	37.8	17333321
1991	21.5	3.62	606474	38.2	18200068
1992	20.5	4.00	633256	38.8	19040019
1993	18.5	4.19	613205	39.1	19736833
1994	17.2	4.25	660788	39.9	20776723
1995	18.4	4.29	735412	44.9	21720066
1996	22.2	4.46	804596	46.0	22840829
1997	20.6	4.57	819199	46.8	24127732
1998	14.4	5.00	685256	47.0	25098375
1999	19.3	5.00	755978	48.0	26294983
2000	30.3	4.87	878175	48.0	28107116
2001	25.9	5.10	886152	48.0	29218947
2002	26.1	5.41	918484	48.0	30324250
2003	31.2	5.61	1033580	48.7	31435587
2004	41.4	5.94	1262887	49.5	33335345
2005	56.5	6.19	1574020	49.9	35293238
2006	66.1	6.43	1925497	49.5	37858675
2007	72.4	7.03	1946145	49.3	40029851
2008	99.6	7.43	2442253	47.6	41279144
2009	61.6	7.71	2146533	45.6	40320344
2010	79.4	8.10	2462516	46.2	41894856
2011	95.0	8.26	2065377	46.8	43524835

Approximations are based on author's calculations

5 Results

OPEC Result
Estimated Correlation Matrix of Variables
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	LY	LPE	LRGDP
LY	1.0000	.87959	.95551
LPE	.87959	1.0000	.96334
LRGDP	.95551	.96334	1.0000

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High correlation is expected between dependent and explanatory variables, the results conforms to what was expected. But the most interesting finding is that high correlation exists between the explanatory variables, meanwhile low correlation was expected.

Ordinary Least Squares Estimation OPEC (long-run)
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Dependent variable is LY 25 observations used for estimation from 1987 to 2011
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Regressor	Coefficient	Standard Error	T-Ratio[Prob]
C	-8.9687	1.2279	-7.3041[.000]
LPE	-.26616	.093980	-2.8321[.010]
LRGDP	.83340	.11127	7.4902[.000]

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R-Squared	.93625	R-Bar-Squared	.93045
S.E. of Regression	.075605	F-stat. F(2, 22)	161.5462[.000]
Mean of Dependent Variable	1.6166	S.D. of Dependent Variable	.28669
Residual Sum of Squares	.12576	Equation Log-likelihood	30.6801
Akaike Info. Criterion	27.6801	Schwarz Bayesian Criterion	25.8518
DW-statistic	.93156		

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Diagnostic Tests
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* Test Statistics *	LM Version	*	F Version	*

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* A:Serial Correlation*	CHSQ(1)= 4.8022[.028]*	F(1, 21)= 4.9930[.036]*
* B:Functional Form *	CHSQ(1)= 6.8399[.009]*	F(1, 21)= 7.9095[.010]*
* *	*	*
* C:Normality *	CHSQ(2)= .64041[.726]*	Not applicable *
* *	*	*
* D:Heteroscedasticity*	CHSQ(1)= .38282[.536]*	F(1, 23)= .35767[.556]*

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A:Lagrange multiplier test of residual serial correlation
B:Ramsey's RESET test using the square of the fitted values
C:Based on a test of skewness and kurtosis of residuals
D:Based on the regression of squared residuals on squared fitted values

Ordinary Least Squares Estimation Opec(Short-run)
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Dependent variable is DLY 24 observations used for estimation from 1988 to 2011
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Regressor	Coefficient	Standard Error	T-Ratio[Prob]
C	.039159	.0064917	6.0322[.000]
DLPE	-.2887E-3	.6822E-3	-.42317[.676]
DLRGDP	.1800E-7	.4272E-7	.42143[.678]

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R-Squared	.010259	R-Bar-Squared	-.084002
S.E. of Regression	.030066	F-stat. F(2, 21)	.10883[.897]
Mean of Dependent Variable	.039381	S.D. of Dependent Variable	.028877
Residual Sum of Squares	.018983	Equation Log-likelihood	51.6527
Akaike Info. Criterion	48.6527	Schwarz Bayesian Criterion	46.8856
DW-statistic	2.1745		

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Diagnostic Tests
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* Test Statistics *	LM Version *	F Version *

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* A:Serial Correlation*	CHSQ(1)= .19407[.660]*	F(1, 20)= .16305[.691]*
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* B:Functional Form *	CHSQ(1)= .33597[.562]*	F(1, 20)= .28395[.600]*
* *	*	*
* C:Normality *	CHSQ(2)= .19414[.907]*	Not applicable *
* *	*	*
* D:Heteroscedasticity*	CHSQ(1)= .39644[.529]*	F(1, 22)= .36951[.549]*

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A:Lagrange multiplier test of residual serial correlation
B:Ramsey's RESET test using the square of the fitted values
C:Based on a test of skewness and kurtosis of residuals
D:Based on the regression of squared residuals on squared fitted values

OECD Results
Estimated Correlation Matrix of Variables
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	LY	LPE	LRGDP
LY	1.0000	.54712	.85607
LPE	.54712	1.0000	.85974
LRGDP	.85607	.85974	1.0000

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High correlation is expected between dependent and explanatory variables and the result above do not conform to what was expected because the correlation between oil price (LPE) and demand (LY) is somewhat low. Secondly, the most interesting finding is that high correlation exists between the explanatory variables, meanwhile low correlation was expected.

Ordinary Least Squares Estimation OCED(Long-run)
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Dependent variable is LY 25 observations used for estimation from 1987 to 2011
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Regressor	Coefficient	Standard Error	T-Ratio[Prob]
C	-3.7525	.73600	-5.0986[.000]
LPE	-.13126	.027324	-4.8040[.000]
LRGDP	.46801	.047710	9.8096[.000]
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R-Squared	.86962	R-Bar-Squared	.85777
S.E. of Regression	.041848	F-stat. F(2, 22)	73.3691[.000]
Mean of Dependent Variable	3.7914	S.D. of Dependent Variable	.11096
Residual Sum of Squares	.038528	Equation Log-likelihood	45.4670
Akaike Info. Criterion	42.4670	Schwarz Bayesian Criterion	40.6387
DW-statistic	.91069		
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Diagnostic Tests
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* Test Statistics *	LM Version *	F Version
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* A:Serial Correlation*	CHSQ(1)= 7.0386[.008]*	F(1, 21)= 8.2293[.009]*
* * *	*	*
* B:Functional Form *	CHSQ(1)= .10167[.750]*	F(1, 21)= .085750[.773]*
* * *	*	*
* C:Normality *	CHSQ(2)= 1.5201[.468]*	Not applicable *
* * *	*	*
* D:Heteroscedasticity*	CHSQ(1)= .98153[.322]*	F(1, 23)= .93990[.342]*
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   A:Lagrange multiplier test of residual serial correlation
   B:Ramsey's RESET test using the square of the fitted values
   C:Based on a test of skewness and kurtosis of residuals
   D:Based on the regression of squared residuals on squared fitted values

Ordinary Least Squares Estimation OECD (Short-run)
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Dependent variable is DLY 24 observations used for estimation from 1988 to 2011
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Regressor	Coefficient	Standard Error	T-Ratio[Prob]
C	-.013263	.015787	-.84015[.410]
DLPE	-.0099186	.028702	-.34558[.733]
DLRGDP	.52225	.32636	1.6002[.124]
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R-Squared	.11686	R-Bar-Squared	.032750
S.E. of Regression	.027884	F-stat. F(2, 21)	1.3894[.271]
Mean of Dependent Variable	.010932	S.D. of Dependent Variable	.028352
Residual Sum of Squares	.016328	Equation Log-likelihood	53.4608

| Akaike Info. Criterion | 50.4608 | Schwarz Bayesian Criterion | 48.6937 |
| DW-statistic | 1.4880 | | |

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Diagnostic Tests

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| * Test Statistics | * | LM Version | * | F Version | * |

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* A:Serial Correlation* CHSQ(1)= 1.6957[.193]*   F(1, 20)= 1.5206[.232]*
*   *   *   *
* B:Functional Form   * CHSQ(1)= 2.3550[.125]*   F(1, 20)= 2.1760[.156]*
*   *   *   *
* C:Normality   *   CHSQ(2)= 129.1340[.000]*   Not applicable   *
*   *   *   *
* D:Heteroscedasticity* CHSQ(1)= .31888[.572]*   F(1, 22)= .29624[.592]*

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A:Lagrange multiplier test of residual serial correlation
B:Ramsey's RESET test using the square of the fitted values
C:Based on a test of skewness and kurtosis of residuals
D:Based on the regression of squared residuals on squared fitted values

6 Conclusion

Obtaining reliable estimates for energy demand models is difficult due to limitations of existing techniques. A log-linear specification is used to represent the long-run demand for energy in a convenient form and because it has been found to work well in previous studies using error correction methods.

For the OECD region, in the long-run oil-price and Real GDP was found to have significant impact on demand with coefficient of -.13126 and .46801 respectively; T-ratio was -4.8 and 9.8. In the short-run oil-price has no impact on demand corresponding to what Keynesian vein assumes "prices are rigid in a short-run; while Real GDP has slight impact.

For the OPEC region, in the long-run oil-price and Real GDP was found to have moderate impact on demand compare to the OECD's. Having coefficient of -.26616 and .83340 respectively T-ratio was -2.8 and 7.84. Further, in the short-run oil-price and Real GDP were found to have no significant impact on demand for the OPEC countries. We concluded that increase in oil-price leads to a transfer of income from OECD to OPEC countries through a shift in the terms of trade. The OECD demand would depend on how much the OPEC countries re-spent this income on OECD goods in order to balance demand and supply gap. If the money is not fully re-spent on OECD products then there will be a sort of disruption in the financial cycle. For example let's assume the money was spent on Chinese products then this might affect the demand for OPEC oils from OECD region. Increases in price will negatively affect oil demand in a long-run especially for oil importers such as the OECD and Real GDP positively affects demand for energy. Energy demand is associated with the positive emission of payment to OPEC member countries leading to creation of "trade deposit" while purchase of OECD goods by OPEC countries is associated with negative emission of payment leading to the destruction of "trade deposit". Perhaps, given the above scenario the demand and supply

gap is closed; otherwise any obstruction to this relationship will have macroeconomic consequences.

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