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Trade and Energy Consumption in the OPEC Countries

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Over the past 50 years many economies have experienced large increases in their international trade volume, national income and energy consumption. In 2010, the world GDP growth rate was 3.6%. In the same year, the rate of international trade growth in developed countries was 12.9% and in the developing countries and common-interest countries combined together growth was 16.7%. Total energy consumption in the world increased from 8,132 million tons in 1990 to 11,099 million tons in 2007. All these bring up an interesting question: how increases in international trade influence energy consumption in different countries. This study uses panel data estimation techniques to examine the impact of international trade on energy consumption in a sample of ten OPEC countries during 1985 to 2009. We also examine the impact of GDP and energy prices on energy consumption. The results show a statistically significant relationship between energy consumption and trade. Therefore, an increase in trade affects energy demand in these countries. This could have implications for energy as well as environmental policies.

1. Introduction

Energy has been considered as an important production factor for decades; its price and availability play key roles in the economic growth of almost all countries. Economic growth and development are considered the main objectives for all nations and the energy market seems to play a prominent role in determining whether nations grow, stagnate, or contract. The increased price of energy and the move to a more efficient energy consumption strategy can have marked effects on economic growth in many countries. This paper deals with energy consumption and trade volume in OPEC countries, where energy is cheap and plentiful, but where there is significant pressure to increase energy prices to reflect market conditions.

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International trade requires a well-functioning transportation network and transportation consumes energy in moving goods by air, rail, road, water and pipeline. Approximately 30% of total global energy demand is derived from the transportation sector (*International Energy Agency*, *US EIA*, *2010*). The relationship between energy consumption and trade is an attractive topic to study for several reasons. If energy consumption has a significant effect on exports and imports, then any reduction in energy consumption, or any energy conservation polices, could potentially reduce the volume of trade. In such circumstances energy conservation polices could be at odds with trade liberalization polices.

2. Economic growth, trade and energy

Over the past 50 years, many developing economies have experienced rapid increases in trade, income, and energy consumption; experiencing a concomitant improvement in economic well-being. In 2011, world real GDP growth was 2.8%, while world primary energy consumption grew by 2.5% (roughly in line with the 10-year average). Crude oil accounted for 33.1% of world energy consumption in 2011 (*British Petroleum Statistical Review of World Energy*, *2012*).

Energy prices, trade liberalization, and improvements in transportation technology have been crucial factors in increasing world trade. According to a 2010 WTO report the value of total world export of goods and services reached 19 trillion dollars and was growing at 14.5% per year. Trade volume in developed countries and developing countries grew 12.9% and 16.7%, respectively, in 2010. At the same time OPEC members experienced rising economic growth and international trade coupled with rapid energy consumption increases. International trade in OPEC countries was generally influenced by oil exports.

In recent years some OPEC countries have tried to improve their economic conditions by joining the WTO (Saudi Arabia has been a member since 2005; Iran and Iraq have been accepted as observer states). Along with increased economic growth came increased demand for energy in these WTO member countries. Over the 2006- 2030 period, it is predicted that energy demand will grow at an average annual rate of 3.2% for the Middle East, 1.4% for Africa and 2.0% for Latin America (International Energy Agency, 2008).

Since the oil shocks of the 1970s a huge literature has developed looking into the relationship between energy consumption and GDP (Yemane, 2009 and Mehrara, 2007)). In particular, an emphasis has been on whether higher energy prices will lead to lower GDP growth. There is a vast literature looking into the relationship between economic growth and energy consumption in different countries. Chien-Chiang and Chun-Ping (2008) examined this relationship within a multivariate panel data framework that includes capital stock and labor input for sixteen Asian countries during the 1971-2002 period. The empirical results fully support a positive long-run co-integrated relationship between real GDP and energy consumption. Mehrara (2007) examined the causal relationship between per capita energy consumption and per capita GDP in a panel of eleven selected oil exporting countries. His results show strong, unidirectional causality from economic growth to energy consumption for oil exporting countries. The results also show that energy conservation (through reforming energy price policies) has had no significant damaging effect on economic growth for this group of countries. Yemane (2008) re-examined the causal relationship between energy consumption and economic growth for seventeen African countries in a multivariate framework by including labor and capital as additional variables. Rufeals (2009) used a multivariate modified Granger causality analysis to study the relationship between energy consumption and economic growth for seventeen African countries during 1970 - 2007. His findings showed no significant relation in fifteen out of the seventeen countries. In fact in eleven out of the seventeen countries, energy was just a contributing factor to output growth and not an important one when compared to capital and labor. Zamani (2007) investigated the causal relationship between GDP and energy consumption using a Vector Error Correction model for the case of Iran during 1967–2003. His results showed that causality was running from GDP to total energy consumption in the long run and a two-way relation between GDP and the consumption of petrochemical and petroleum products.

The studies that have been performed on the relationship between economic growth and energy consumption for different countries do not exhibit the same results for all economies. Furthermore, there is a gap in the literature in that there are no studies which examine the relationship between energy use, exports and GDP within a single multivariate model. Theoretically, there are some reasons exports can affect energy consumption. Machinery and equipment must be used to load and transport exports to seaports, airports or to other station where the goods are then offloaded and re-loaded for voyages abroad (Perry, 2011). The machinery and equipment used in the process of producing and transporting goods for export needs energy to operate. An increase in exports leads to an increase in economic operations and this should increase demand of energy. So without energy, export expansion will falter. Finally, we can say that energy is an essential factor in export expansion.

In this paper we also investigate the relationship between energy consumption and imports. Theoretically, the volume of imports influences energy consumption in two ways. First imports could substitute for domestic production, which would tend to reduce the amount of energy used. The second depends on the composition of imported goods and how they are used. If the composition of imported goods is mostly durables, such as automobiles, air conditioners, etc., the use of energy would be higher and an increase in these types of imported goods would increase the demand for energy. After the oil price hikes in 1973 and 1979 energy demand in oil exporting countries increased. But in most oil exporting countries the growth of energy consumption per capita was much higher than their economic growth. The gap between energy consumption and economic growth in Kuwait was the greatest, and Saudi Arabia was in second position among 11 oil exporting countries.

Increasing energy consumption in oil exporting countries is concerning. Iran consumed 1.9 million barrels of oil per day in 2012. This level of energy consumption is equal to energy consumption in Spain, which has a GDP three times greater than Iran. This level of energy consumption is more than daily energy consumption in Spain (which consumed only 1.2 million barrels of oil per day), which had a GDP approximately 2.5 times greater than Iran *(British Petroleum Statistical Review of World Energy, 2013)*. This is a concern for policy makers in OPEC countries where energy consumption is quite high given GDP levels. If a strong relationship exists between energy consumption and economic growth, then reductions in energy consumption will potentially result in lower economic growth as energy price adjustments are made. However, if no causal relationship between energy consumption and GDP exists, energy conservation policies can take place without harming economic growth.

If a statistically significant relation between energy consumption and trade exists, then energy consumption will impact the volume of trade.

3. Literature Review

Narayan and Smyth (2009) examined the causal relationship between electricity consumption, exports and GDP for a panel of Middle Eastern countries. The results show that there are statistically significant feedback effects among these variables. They found that a 1% increase in electricity consumption increases GDP by 0.04%, a 1% increase in exports increases GDP by 0.17% and a 1% increase in GDP generates a 0.95% increase in electricity consumption. One of the policy implications of their work is that promoting exports, particularly non-oil exports, is a means to speed up economic growth and it can be realized without having adverse effects on energy conservation policies.

Lean and Smyth (2010) employed annual data for Malaysia from 1970 to 2008 to examine the causal relationship between economic growth, electricity generation, exports and prices in a multivariate model. They found that there is unidirectional Granger causality running from economic growth to electricity generation. The policy suggestion of their paper is that electricity conservation policies, including efficiency improvement measures and demand management policies which are designed to reduce wastage of electricity, can be implemented without having an adverse effect on Malaysia’s economic growth.

Sadorsky (2011) used panel co integration estimation techniques to examine the impact of trade on energy consumption in a sample of eight Middle Eastern countries during 1980-2007. Short-run dynamic analysis showed Granger causality from exports to energy consumption and a bi-directional feedback relationship between imports and energy consumption. The long-run elasticities estimated from Fully Modified Ordinary Least Squares (FMOLS) showed that a 1% increase in per capita exports increases per capita energy consumption by 0.11% while a 1% increase in per capita imports increases per capita energy consumption by 0.04%.

In another study Perry (2012) used panel co-integration regression techniques to examine the relationship between energy consumption, output and trade in a sample of seven South American countries during

1980 - 2007. The results showed a long-run relationship between 1) output, capital, labor, energy consumption and exports and 2) output, capital, labor, energy consumption and imports. The analysis of short-run dynamics showed a bi-directional feedback relationship between energy consumption and exports, output and exports and output and imports. There was also evidence of a one-way, short-run relationship from energy consumption to imports. The results had implications for energy and environmental policy. One important implication of the results is that environmental policies designed to reduce energy use reduce trade. This puts environmental policy aimed at reducing energy consumption at odds with trade policies.

4. Empirical Model

Total energy demand, E, in country *i* at time period *t*, can be written as a function of energy price, P, income, Y, and trade, O.

$$E_{it} = f(Y_{it},, P_{it,} , O_{it,}) \qquad (1)$$

or specified in *log* linear form:

$$E_{it} = Y^{\alpha}_{it} P^{\beta}_{it} O^{\gamma}_{it} \qquad (2)$$

Taking natural logarithms of Equation (2), denoting lower case letters as the natural log of upper case letters and adding a random error term produces the following equation**.**

$$e_{it} = \alpha_i y_{it} + \beta_i p_{it} + \gamma_i o_{it} + \varepsilon_{it} \qquad (3)$$

In Equation (3), countries are specified by the subscript *i* ($i= 1, \ldots, N$) and the subscript *t* denotes the time period ($t= 1,\ldots, T$). Equation (3) is a fairly general specification which allows for individual fixed country effects (υ), and a stochastic error term (ε). In practice, trade openness is measured using either exports (ex) or imports (im). In this analysis we are interested in their differential effects because exports likely influence energy consumption in a different way than imports.

Our objective is to study the effect of exports and imports on energy consumption. This paper uses panel co-integration techniques to investigate the relationship between energy consumption and trade in a sample of OPEC economies. The data set is a balanced panel of ten OPEC countries during 1985–2009. We use Sadorsky's (2011) model which includes annual data on energy consumption, income, energy prices and trade. The data includes as many countries as possible with a reasonable time length of observations. The OPEC countries included in the sample are: Algeria (AL), Angola (AN), Ecuador (EC), Iran (IR), Kuwait (KU), Libya (LI), Nigeria (NI), Qatar (QA), Saudi Arabia (SA), and Venezuela (VE). Iraq and United Arab Emirates were omitted due to a lack of data.

Data on per capita energy consumption, exports and imports are obtained from the World Bank World Development Indicators online data base. Data on real GDP per capita, consumer prices and population are obtained from the Penn World Tables version 7. The price of Dubai crude oil is from British Petroleum's 2010 Statistical Review of World Energy. Energy price data are not easily available for all countries and so a proxy real energy price variable for each country is constructed by deflating the price of Dubai crude oil (measured in US dollars) to the country's consumer price index (Sadorsky, 2011). Real GDP per capita is measured in constant dollars using the PPP converted chain series with constant 2005 prices. The raw data for exports and imports are nominal exports and imports measured in current US dollars. These values are deflated by the country's consumer price index relative to US prices using purchasing power parity. These real export and import values are then converted to per capita values. The resulting data series are real per capita exports and imports.

5. Diagnostics Tests

The Chow test was used to choose between a fixed effects model and a pooled model for the countries. A Hausman test was performed to select between the fixed effects models and random effects models. The F-statistic for the Chow test was 456, so we conclude that we cannot pool our data and a fixed effects model should be used. The Chi-Square statistic for the Hausman test is 22.94, indicating that we should use a fixed effect model as opposed to a random effects model.

In this paper four types of panel unit root tests are performed – proposed by Levin et al. (2002); Im et al. (2003); Dickey and Fuller (1979) and Phillips and Perron (1988). The tests proposed by Levin et al. (2002)

assume that there is a common unit root across the cross-sections. For this test, the null hypothesis is that there is a unit root while the alternative hypothesis is that there is no unit root. The other tests assume individual unit root processes across the cross-sections. For these tests, the null hypothesis is that there is a unit root while the alternative hypothesis is that some cross sections do not have a unit root. For each series in levels the null hypothesis of a unit root cannot be rejected at the 5% level while for each series in the first differences, the null hypothesis of a unit root can be rejected (Table 1).

Table 1: Panel Unit Root Tests.

Δ log im	**log im**	**Δ log ex**	**log ex**	**Δ log y**	**log y**	**Δ log p**	**log p**	**Δ log e**	**log e**	
-4.1863	0.3903	-5.4528	0.9172	-8.4022	-0.7701	-5.4463	-2.0241	-11.025	0.2931	**Levin, Lin, Chu**
0.000	0.6518	0.000	0.8205	0.000	0.2206	0.000	0.0215	0.000	0.6153	**Prob.**
-3.8853	0.9906	-4.5259	0.3669	-9.2124	0.4816	-10.253	-0.7896	-12.808	-0.1607	**Im, Pesaran, Shin**
0.000	0.8391	0.000	0.6432	0.000	0.6850	0.000	0.2149	0.000	0.4363	**Prob.**
79.943	19.898	79.310	19.669	109.86	28.907	123.58	31.923	153.97	28.710	**ADF-Fisher**
0.000	0.5894	0.000	0.6037	0.000	0.1475	0.000	0.0787	0.000	0.1533	**Prob.**
92.9067	14.3623	84.7690	20.4277	130.944	14.7629	153.501	22.5103	197.046	20.080	**PP-Fisher**
0.000	0.8881	0.000	0.5563	0.000	0.8722	0.000	0.4298	0.000	0.5780	**Prob.**

All unit root test regressions were run with a constant and deterministic time trend

The results were tested for co-integration using the tests of Pedroni (1999) and (2004). Pedroni's approach for panel co-integration uses the residuals from the empirical model (equation (3)) to test for a unit root (assuming no trend or drift in the estimated equation).

$$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + \xi_{it} \qquad (4)$$

Pedroni (1999) and (2004) provides seven statistics for tests of the null hypothesis of no co-integration in heterogeneous panels. These tests can be classified as either within-dimension (panel tests) or between dimensions. These tests are all based on the residuals from Equation (3). For the within-dimension approach, the null of no co-integration ($\rho i = 1$ for all *i*) is tested against the alternative of $\rho_i = \rho < 1$ for all *i*. The results from performing these tests in a system of variables that includes imports are somewhat mixed with five of the statistics indicating co-integration at the 10% level (table 2). The analysis was performed assuming that *e*, *y*, *p* and *ex* are co-integrated and that in a separate system *e*, *y*, *p*, and *im* are co-integrated.

Table 2: Cointegration Tests.

Panel cointegration test (e, y, p, im)	***Statistics***	***Prob***	Panel cointegration test (e, y, p, ex)	***Statistics***	***Prob***
Panel v-Statistic	0.421	0.33	***Panel v-Statistic***	-0.128	0.55
Panel rho-Statistic	1.945	0.87	***Panel rho-Statistic***	0.87	0.80
Panel PP-Statistic	-3.579	0.00	***Panel PP-Statistic***	-4.537	0.00
Panel ADF-Statistic	-3.932	0.00	***Panel ADF-Statistic***	-2.91	0.00
Group rho-Statistic	2.693	0.99	***Group rho-Statistic***	2.453	0.99
Group PP-Statistic	-3.227	0.00	***Group PP-Statistic***	-3.687	0.00
Group ADF-Statistic	-2.248	0.00	***Group ADF-Statistic***	-1.718	0.00

Granger causality test results for the energy demand and exports are presented in table 3. We use a 5% level of significance to interpret the results. The results show significant Granger causality from income to energy consumption, income to exports and from exports to energy consumption. These results provide evidence of a feedback relationship between income and energy consumption, and a feedback relationship between income and exports.

Table 3: Granger Causality Results for Energy, GDP, Oil Price, and Exports[a]

to / from	**Δe**	**Δy**	**Δp**	**Δex**
Δe		2.32 (0.03)	1.76 (0.09)	2.08 (0.05)
Δy	6.33 (0.00)		2.56 (0.02)	4.56 (0.00)
Δp	2.07 (0.06)	5.45 (0.00)		0.78 (0.65)
Δex	2.35 (0.02)	5.89 (0.00)	1.78 (0.04)	

[a]F statistics with p value in parentheses

The results of Granger causality tests between energy, income, imports and oil price are presented in table 4. They show a feedback relationship between imports and energy consumption.

Table 4: Granger causality results for Energy, GDP, Oil Price, and Imports[b]

to / from	**Δe**	**Δy**	**Δp**	**Δex**
Δe		2.46 (0.03)	2.01 (0.08)	2.30 (0.03)
Δy	3.50 (0.00)		4.46 (0.00)	3.49 (0.00)
Δp	0.78 (0.80)	6.12 (0.00)		1.23 (0.20)
Δim	2.58 (0.01)	3.49 (0.00)	1.35 (0.14)	

[b]F statistics are reported with p value in parentheses

6. Empirical Results and Discussions

The results of estimating the OLS regression are shown in table 5.

Table 5: Results of the Regression Explaining Energy Consumption in OPEC Countries

variable	coefficient	t-statistic	Prob.
C	5.1422	7.4256	0.0000
Y	0.1010	1.1799	0.2393
EX	0.4014	7.8340	0.0000
P	-0.1181	-2.4754	0.0014
IM	-0.2656	-6.7605	0.0000

R^2 = 0.98; adjusted R^2 = 0.98; F-statistic = 880 (p=0.00)

The regression results show that there is a statistically significant relationship between trade (exports and imports) and energy consumption. A 1% increase in exports increases energy consumption by 0.40% in OPEC economies (table 5). This is in line with Sardorsky's (2011) findings. A 1% increase in imports reduces energy consumption by 0.27. OPEC countries are not very efficient users of energy (as stated earlier) so the energy content of their exports is more intensive than their imports. Of course this reflects their dependence on oil and petroleum product exports, and food and industrial good imports. There is a negative relationship between energy consumption and energy price that is statistically significant and is supported by economic theory; if the energy price increases by 1%, energy consumption will decrease by 0.12%. GDP is also positively related to energy consumption; if GDP increases by 1% energy consumption increases by 0.10%.

7. Conclusions

Energy, as an important input in the manufacturing sector, has a special role in growth and economic development. In this paper we estimate the relationship between trade and energy consumption in OPEC countries during 1985-2009. The results show that an increase in exports will increase energy consumption but an increase in imports will decrease energy consumption in OPEC countries. Since a large part of exports for OPEC economies is oil, the export growth in these countries means an increase in extraction activities and crude oil refinement that all require large amounts of energy. The coefficient on exports is the largest, implying that exports are most energy intensive. The coefficient on GDP is 0.10 implying that increasing GDP (or production of goods and services in OPEC countries) is less energy intensive than exports. Finally, if an OPEC country imports a good rather than producing it themselves they reduce energy use by 0.40 – 0.27 = 0.13.

The countries that are generally rich in energy resources usually pay less for energy. In many cases this could cause waste. With the finding of a negative relationship between energy consumption and energy price energy waste can be reduced by allowing energy prices to increase to its world price level. Granger causality tests show a causality relationship from exports to energy consumption. This implies that the policy of increasing exports will increase the demand for energy but energy reduction policies will not affect export growth in OPEC countries. We also found a feedback relationship between imports and energy consumption. Since an increase in imports requires energy, conservation policies will reduce OPEC country imports.

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