THE ESTIMATE OF OIL DEMAND FUNCTION OF IRAN’S OIL IMPORTING COUNTRIES

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ABSTRACT
Oil has been the major source of energy since the beginning of the 20th century; and oil market experts and agencies specialized in energy believe that oil will supply a major part of the energy needed by countries in the 21st century. From both the political and economic aspects the issue of oil export is of the utmost importance for the Islamic Republic of Iran. In the economic dimension the enormous volume of oil export revenues obtained for many years have caused severe dependence of economy and the government annual budget on oil revenues. So the purpose of this paper is to estimate the crude oil demand function for countries importing Iran’s oil using panel data over the period 1975-2010. The results show that crude oil demand is relatively inelastic in terms of price and income, but income elasticity of crude oil is greater than price elasticity; in other words, changes in economic growth are more effective compared to the changes in crude oil prices.

Key words: estimation of crude oil demand, price and income elasticity, panel data

JEL Classification: C1, C13, C23, Q31

INTRODUCTION

Oil has been the main source of energy from the beginning of the 20th century and it has obvious advantages compared to other sources of energy. The reasons for this are ease of access and transport, variety and low prices, and thus having a detailed structure of the demand cycle. Oil market experts and agencies specialized in energy believe that oil will supply a major part of the energy needed by countries in the 21st century. Existing statistics indicate that oil demand from 76.3 million barrels per day in 2000 has reached 91.4 million bpd in 2013 (1). Oil is important regarding many aspects. All countries require oil as the selected fuel in the transport sector. Due to the cars, trailers, airplanes and ships using exclusively oil production for the fuel of their engines, so the oil dominates continually the part of the economic structure which is properly interpreted as the network of blood vessels. Any issue that affects the transport sector causes substantial losses to the economy that in many cases it can disturb the economy, so that oil is a strategic commodity.

The issue of oil security has led to the importance of oil in the global economy and it has resulted in extensive interaction between energy and politics.
Many friendships, rivalries and political evolution in the world are affected by the energy. Having predominance over most of oil reserves in the world is one of the main levers of domination and superiority for superpowers.

The oil-exporting countries are in critical need of oil revenues due to the economic development and social welfare. All oil-exporting countries except Canada, Norway, Russia and some other countries are among the third world countries. Most of them have a large population and consequently have low per capita income. These countries due to the lack of time and other resources which are needed for diversification of economic activities are highly dependent on oil export revenues. The establishment of foundation for self-sufficient economic growth which is independent of oil is a long-term challenge, so for these countries oil is quite a strategic commodity.

According to the statistics of 2007 Iran was fourth in the ranking of major oil exporter in the world. In that year an average of 2.45 million barrels of oil was exported from Iran per day that 60% of it was exported to the countries in Asia, 32% to Europe and the rest was exported to Africa. (Central Bank of Iran). Due to the high amount of foreign exchange earnings obtained from oil exports in our country (Iran) and country’s economic dependence on these revenues (table 1) study of oil demand of countries importing oil from Iran is necessary and essential because the estimation of oil demand function of countries importing oil and analysis of factors affecting their demand can be effective in planning and policy making conducted by our economic system officials and therefore be efficient to solve the economic problems because by having accurate prediction of income obtained from oil exports, it would be more facile to plan for economic development and social welfare. In this paper, oil demand of China, India, Japan, Korea, Turkey, Italy, Spain and Greece, which are the major buyers of Iranian oil, is inspected.
Table 1: Trend of Iran's oil revenues-dollar

<table>
<thead>
<tr>
<th>Year</th>
<th>oil revenues(dollar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>57,619,000,000</td>
</tr>
<tr>
<td>2007</td>
<td>66,214,000,000</td>
</tr>
<tr>
<td>2008</td>
<td>87,050,000,000</td>
</tr>
<tr>
<td>2009</td>
<td>56,342,000,000</td>
</tr>
<tr>
<td>2010</td>
<td>71,571,000,000</td>
</tr>
</tbody>
</table>

Source: Central bank of Iran

MATERIALS AND METHODS

In following we present a summary of the studies that have been conducted in this area inside and outside the country and we introduce the model used in the present report and according to the information and data of the period from 1975 to 2010, the crude oil demand function of aforementioned countries is estimated, so that by conducting the analysis of the crude oil demand in these countries, we will be able to carefully provide forecasts and strategies for dealing with probable issues.

Dargy and Gately (1995) estimated the demand function for oil products non-transport sector for both symmetric and asymmetric demand. Implementing the method of price decomposition for three different components they concluded that from Statistical analysis point of view demand for oil and other products is asymmetric apart from transport sector. Using the same method, Taghavi Nejad (2002) inspected the asymmetry of the crude oil demand function in developed countries of the G7 and developing countries of ECO from 1965 to 2000. Manzour and Niakan (2014) adopted uniform panel threshold regression model in order to describe the energy demand function for ECO member countries are considering time between period 1990 to 2008. According to this study the income elasticity of in these countries is less than unit and therefore energy demand is relatively inelastic compared to income.

Using panel data method and analyzing the relationship between crude oil demand and economic growth in the Middle East countries Soori and et al (2011) by analyzing the relationship between crude oil demand and economic growth in the Middle East countries using annual data 1980-2007 and also using panel data concluded that Crude oil demand is
asymmetric in terms of price and income and economic growth is the most important factor influencing the growth of crude oil consumption in these countries. Cooper (2003) by using data on crude oil price and GDP over the period 1971 to 2000 uses a multiple regression model derived from an adoption of Nerlove’s partial adjustment model to estimate both the short-run and long-run elasticizes of demand for crude oil in 23 countries. The estimate so obtained that the demand for crude oil internationally is highly insensitive to changes in price, has estimated price elasticity of demand for crude oil in the short and long run for 23 countries.

By a study designed to measure the world economy’s dependence on Persian Gulf oil resources, Rahbar and Robati (2010) dealt with the estimation of global oil demand function for this region and measurement of income and price elasticity by autoregressive distributed lag model (ARDL). Javaheri and Rezayi (2010) studied oil demand of India, which is one of the major buyers of Iranian crude oil, for the period 1970-2005. In this study the impacts of the variables of GDP, the price of crude oil, the shares of transport and industrial sectors in GDP and oil consumption of the previous period on this country’s oil demand have been investigated. The outcome of this study suggests that the price elasticity of crude oil is 0.09 and the income elasticity of crude oil demand is 1.08. The variables of the transport and industry and oil consumption of the previous period were not significant.

Based on studies conducted on oil demand generally, the major determinants of oil demand are: Income (Economic Growth Rate), price, Technology of means that apply oil, Changes in consumer tastes, part of which is dependent on income (the indicator of standards of living), government energy policies and having access to the competing substitute in the cases that use of the substitute is feasible as regards technology. It is clear that in the fixed condition, income growth increases demand and increase in price leads to reduction in demand in the oil market. Generally, by studying the models presented in the context of oil demand it can be concluded that in these models, mostly oil prices and GDP and the dependent variable with a time lag were entered as the independent variables. Therefore, in this study in order to estimate the demand for crude oil we have adopted the logarithmic equation similar to the model used in many studies such as Dargy and Gatly (1995), and Cooper (2003):

\[ \ln D_t = \beta_1 + \beta_2 \ln P_t + \beta_3 \ln Y_t + \beta_4 \ln D_{t-1} + \epsilon_t \]  \hspace{1cm} (1)

Where:
\(D_{it}: \) Crude oil demand for country i in year t

\(P_{it}: \) Real price of crude oil in year t, (At fixed of 2005)

\(Y_{it}: \) Real GDP (At fixed price of 2005) in the country i in year t

\(D_{it-1}: \) Crude oil demand in country i in year t-1

\(\varepsilon_{it}: \) Assumed random error term

\(\text{Ln}=\) Natural logarithm

\(\beta_1, \beta_2, \beta_3, \beta_4\) Are coefficients to be estimated

An attractive feature of such a log linear model is that the coefficient \(\beta_2\) can be interpreted as the short-run price elasticity of demand and \(\beta_2 / (1 - \beta_4)\) as the long-run price elasticity of demand.

Cooper by the method of Nerlove’s partial adjustment proved the equation (1) as follows. If function of the long-term demand for crude oil is as inequation (2):

\[D_{it} = aP_{it}^{\beta}Y_{it}^{\varepsilon}e_i \quad (2)\]

And gradual adjustment process is as equation (3):

\[\frac{D_{it}}{D_{it-1}} = \left[\frac{D_{it}}{D_{t-1}}\right]^d \text{ where } 0 < d < 1 \quad (3)\]

Where:

\(D_{it} = \) long-run demand for oil as in year t

\(D_{it} = \) short-run demand for oil in year t

\(P_{it} = \) Real price of oil in year t

\(Y_{it} = \) Real GDP in year t
e = Random error term

And a, b, c and d are parameters, where:

b = long-run price elasticity of demand for oil

d = coefficient of adjustment

By solving equation (3) in relation to \( D_{t,t} \) the following equation is obtained:

$$
D_{t,t} = \left[ \frac{D_{t,t}}{(D_{t-1,t})^d} \right]^{\frac{1}{1-d}}
$$

(4)

Substituting this value for \( D_{t,t} \) in equation (2), the equation (5) is obtained:

$$
\left[ \frac{D_{t,t}}{(D_{t-1,t})^d} \right]^{\frac{1}{1-d}} = aP_t^bY_t^c e_t
$$

(5)

In which:

$$
D_{t,t} = a^{(1-d)}P_t^{b(1-d)}Y_t^{c(1-d)}(D_{t-1,t})^d e_t^{(1-d)}
$$

(6)

Taking the logarithm of both sides of equation (6) we obtain the following equation:

$$
LnD_{a,t} = (1-d) \ln a + b(1-d) \ln P_t + c(1-d) \ln Y_t + dLnD_{t-1,t} + (1-d) \ln e_t
$$

(7)

Equation (7) is in the same form equation (1) in this text, and its theoretical underpinning, which is estimated by Panel-GMM method. The short-run price elasticity of demand is given by \( b(1-d) \) which is corresponds to \( \beta_2 \) in equation (1). Similarly the long-term price elasticity of demand is given by \( b \), which is equivalent to \( \beta_2 + (1 - \beta_1) \) in equation (1).

Demand of the previous period or demand with one lag is one of the other applied variables. The necessity of using the demand with one lag is described as follows:

Consumption is essentially a function of current income, but the incomes of previous years also affect it. This subject is known as the habit persistence hypothesis. The permanent income hypothesis
alsorecommends this lagged variable. According to the permanent income hypothesis, consumption is a function of permanent income:

\[ C_t = \beta Y_t^* \quad (8) \]

In which \( Y_t^* \) is the permanent income. Since \( Y_t \) is not directly measured, we need some hypotheses about its formation. A common hypothesis about the formation of \( Y_t \) is that the value of past incomes is effective on it and incomes of the years closer to the current year have greater influence on its formation, so they have more weight in its calculation. Considering the Koyk distributed lag model we have:

\[ Y_t^* = \lambda Y_t + \lambda^2 Y_{t-1} + \lambda^3 Y_{t-2} + ... \quad (9) \]

Where \( 0 < \lambda < 1 \); If the measure of permanent income is inserted in consumption function:

\[ C_t = \beta \lambda Y_t + \beta \lambda^2 Y_{t-1} + \beta \lambda^3 Y_{t-2} + ... \quad (10) \]

That consumption with one period lag is:

\[ C_{t-1} = \beta \lambda Y_{t-1} + \beta \lambda^2 Y_{t-2} + \beta \lambda^3 Y_{t-3} + ... \quad (11) \]

If the equation (9) is multiplied by \( \lambda \) and the result is deducted from the equation (8), we have:

\[ C_t - \lambda C_{t-1} = \beta \lambda Y_t \quad (12) \]

So the consumption of current period becomes equation 13:

\[ C_t = \lambda C_{t-1} + \alpha Y_t \quad (13) \]

So the existence of lagged variable \( c_{t-1} \) in the total of explanatory variables of current consumption is explained under 3 certain hypotheses in macroeconomic namely Partial adjustment, habit formation and permanent income. Considering all the aforementioned matters the function of crude oil demand is generally specified as equation 14.

\[ D_t = f(P_t, Y_t, D_{t-1}) \quad (14) \]
Crude oil demand and real price data are extracted from British Petroleum (BP), while real GDP are extracted from statistic published by the World Bank (WB). Using annual data for the period 1975 – 2010.

Descriptive statistics
Descriptive statistics of the variables used in this study during the period 1975-2010 are presented in Table 2. The statistics reported include indicators and central criteria such as mean, median and indices of dispersion including variance, standard deviation of the variables used in this study.

Table 2: Descriptive statistics of the variables used in the period 1975-2010

<table>
<thead>
<tr>
<th>Variable</th>
<th>LnY</th>
<th>LnP</th>
<th>LnD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>26.93</td>
<td>3.38</td>
<td>6.92</td>
</tr>
<tr>
<td>Median</td>
<td>26.95</td>
<td>3.42</td>
<td>7.06</td>
</tr>
<tr>
<td>Maximum</td>
<td>29.19</td>
<td>4.38</td>
<td>9.11</td>
</tr>
<tr>
<td>Minimum</td>
<td>24.33</td>
<td>2.24</td>
<td>3.22</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1.14</td>
<td>0.64</td>
<td>1.12</td>
</tr>
</tbody>
</table>

The Evaluation of variables stationarity
In this study before estimating the regression model, the stationarity test is used for all the time series. Too many economic time series are non-stationary and regressions between the more counterfeit, so unit root tests are needed to be conducted to make us capable of determining the degree of accumulation of variables used. If the understudy time series are not stationary, there is no possibility of using regression models due to the occurrence of falseregression problem. The unit root tests are applied in order to conduct the stationarity test. Among the variety unit root tests the test of Levin and others (2002) is the most common and widely used. This test has been conducted for all variables in the model. If the amount of Levin statistic calculated is less than 5%, the null hypothesis suggesting the existence of unit root is rejected and so the specific series is
stationary. Test results for the model variables are presented in the table 3. The results show that all variables are in the level of stationarity.

Table 3: The results of the stationary test of variables during the period of 1975-2010

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levin</th>
<th>Prob</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>LnD</td>
<td>-11.06</td>
<td>0.00</td>
<td>Stationary</td>
</tr>
<tr>
<td>LnP</td>
<td>-5.22</td>
<td>0.00</td>
<td>Stationary</td>
</tr>
<tr>
<td>LnY</td>
<td>-5.19</td>
<td>0.00</td>
<td>Stationary</td>
</tr>
</tbody>
</table>

After conducting the stationarity test for each variable, at this stage we deal with the long term relationship and co integration between the dependent variable and the independent variables by using Kao test for 8 selected countries during 1975-2010. Table(4) shows the convergence test results between variables. Since probability of the Kao statistic is less than 5%, we can say that the null hypothesis suggesting there is no long-term and co integrate relationship between variables, is rejected and alternative-hypothesis meaning the existence of long-term and balanced relationship, is confirmed.

Table 4: Kao co integration test results

<table>
<thead>
<tr>
<th>Co integration test</th>
<th>Statistic</th>
<th>Probability</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kao</td>
<td>-3.04</td>
<td>0.001</td>
<td>The existence of convergence relationship between the variables of the model</td>
</tr>
</tbody>
</table>

Source: Research calculations by Eviews software

In this study we have used the Panel-GMM method for the estimation of equation (1). The estimation results of crude oil demand for the period 1975-2010 are provided in the table(5). Durbin-Watson statistic is used In order to test the absence of autocorrelation in the model. This statistic according to the results of table(5) is close to 2. According to the statistics obtained, hypothesis H0 is accepted and it
can be shown that in this model there is not any autocorrelation. The amount coefficient of determination ($R^2$) in the first estimated model is 99%. Sargan test results indicate that the applied instruments are irrelevant with residuals. Income elasticity was obtained equal to 0.05. The price elasticity of short-term demand is equal to 0.03, while the price elasticity of long-run demand is calculated as follows:

$$e_d = \frac{\beta_2}{1 - \beta_4} = \frac{-0.03}{1 - 0.92} = -0.37$$

Table 5: The estimation results of the crude oil demand by the Panel-GMM method over the period from 1975-2010 (Dependent variable: logarithm of crude oil demand LnD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.62</td>
<td>-2.33</td>
<td>0.02</td>
</tr>
<tr>
<td>LnY</td>
<td>0.05</td>
<td>3.84</td>
<td>0.00</td>
</tr>
<tr>
<td>LnP</td>
<td>-0.03</td>
<td>-4.98</td>
<td>0.00</td>
</tr>
<tr>
<td>LnD(-1)</td>
<td>0.92</td>
<td>60.81</td>
<td>0.00</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D-W</td>
<td>1.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prob (Sargan Test)</td>
<td>0.47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results of estimating the equation of crude oil demand over the period 1975-2010 for the selected countries is shown in table (6). Based on the results obtained it is significant at the 5% level. The estimated coefficients have the expected a priori signs (apart from GDP associated coefficient for country Japan which has been obtained negative.) and it is theoretically acceptable. The coefficient of determination equals 0.99. Price and income coefficients are equal to of price and income elasticity respectively. The long-run price elasticity is between -0.12 and -0.83. The biggest long-run price elasticity is for China and Japan which is -0.83 and -0.45 respectively and the smallest amount is for India and Spain which is -0.12 and -0.13. So Oil demand in China and Japan is
sensitive to changes in oil prices. One reason for the low elasticity of crude oil demand in India and Spain may be the inability of these countries of using new alternative energy for crude oil. The income elasticity range is between -0.01 and 0.18. The biggest short-term income elasticity is for Korea and Greece, which is 0.18 and 0.16 respectively and the smallest amount is for Japan and Turkey, which is respectively -0.01 and 0.02, so the sensitivity of oil demand in Korea and Greece to the GDP is high. So that one percent increase in Korea's GDP leads to 0.18 percent increase in its crude oil demand. The reason for negative income elasticity in Japan may be related to the development of advanced technologies and access to new energy resources in this country, which has led to using less oil.

Table 6: The estimation of price elasticity of oil demand in each country during the period from 1975-2010

<table>
<thead>
<tr>
<th>Country</th>
<th>Oil Consumption % Growth</th>
<th>Real GDP % Growth</th>
<th>Price Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short-run</td>
<td>Long-run</td>
<td>Short-run</td>
</tr>
<tr>
<td>China</td>
<td>5.46</td>
<td>5.69</td>
<td>-0.05</td>
</tr>
<tr>
<td>Japan</td>
<td>5.56</td>
<td>9.09</td>
<td>-0.05</td>
</tr>
<tr>
<td>Italy</td>
<td>6.33</td>
<td>6.83</td>
<td>-0.03</td>
</tr>
<tr>
<td>Turkey</td>
<td>2.01</td>
<td>2.09</td>
<td>-0.02</td>
</tr>
<tr>
<td>Korea</td>
<td>1.83</td>
<td>2.46</td>
<td>0.06</td>
</tr>
<tr>
<td>Greece</td>
<td>-0.64</td>
<td>1.74</td>
<td>-0.04</td>
</tr>
<tr>
<td>Spain</td>
<td>2.63</td>
<td>3.97</td>
<td>-0.02</td>
</tr>
<tr>
<td>India</td>
<td>-0.35</td>
<td>2.46</td>
<td>-0.01</td>
</tr>
</tbody>
</table>
\[\text{LnD} _ \text{India} = -0.80 - 0.01\text{LnP} + 0.07\text{LnY} + 0.92\text{LnD}(-1)\]
\[\text{LnD} _ \text{China} = -0.80 - 0.05\text{LnP} + 0.03\text{LnY} + 0.94\text{LnD}(-1)\]
\[\text{LnD} _ \text{Korea} = -0.80 - 0.06\text{LnP} + 0.18\text{LnY} + 0.79\text{LnD}(-1)\]
\[\text{LnD} _ \text{Greece} = -0.80 - 0.04\text{LnP} + 0.16\text{LnY} + 0.83\text{LnD}(-1)\]
\[\text{LnD} _ \text{Spain} = -0.80 - 0.02\text{LnP} + 0.08\text{LnY} + 0.85\text{LnD}(-1)\]
\[\text{LnD} _ \text{Italy} = -0.80 - 0.03\text{LnP} + 0.03\text{LnY} + 0.92\text{LnD}(-1)\]
\[\text{LnD} _ \text{Turkey} = -0.80 - 0.02\text{LnP} + 0.02\text{LnY} + 0.93\text{LnD}(-1)\]
\[\text{LnD} _ \text{Japan} = -0.80 - 0.05\text{LnP} - 0.01\text{LnY} + 0.89\text{LnD}(-1)\]

**CONCLUSIONS**

In this paper, oil demand function of countries importing Iran's oil was estimated using annual data for the period 1975-2010. The results indicate that crude oil demand in comparison to price is relatively inelastic in short-run, while demand price elasticity is bigger in long-run and the biggest amount of demand price elasticity is for China equal to -0.83 in long-run.

Moreover, the income elasticity of demand for oil importing countries is between -0.01 and 0.18 which belong to Japan and Korea respectively. The reason for Japan's Income elasticity of demand being negative may be related to the economic development of this country that has led to the adoption of advanced technologies and new energy resources in this country, and thus the country's need for oil consumption has been reduced. So in relation to increase the oil exports and benefit from increase in foreign exchange earnings from oil exports, Iran should adopt plans and policies with regard to price and income elasticity of oil demand of importing countries.
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