

Exploring Price Causal Relations of OPEC and Non OPEC Oil Markets: Application of Tetrad Algorithm

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Abstract

Crude oil price dynamics determines the order of the world oil market in which OPEC and Non OPEC countries plays major role as exporters and importers. The co-integration and information flow of crude oil price between these groups of countries is helpful in understanding the oil price dynamics in terms of oil rich and oil dependent countries. In this empirical study we explored whether or not the selected OPEC and non OPEC countries are co integrated, if so what kind of causal information implies between each other and country's dependence or independence in terms of price giver or price taker. Econometrics tools and causal data analysis software tetrad is used in the analysis of oil price time series data.

Keywords: Co integration, Crude Oil Price, Econometrics, Tetrad, Time Series

1. Introduction

The oil market has puzzled many, be it researchers, merchants or even speculators. The era when the oil prices were not volatile have long gone by. Since the year 2000, the prices of oil has lurched from that of a consistent rise to a gradual hike and touched pinnacle in mid 2008. The fundamental reason based on the economic viewpoint is demand supply gap. Though this is one well-known factor that spike up the oil prices, but there are other considerations as well. One can always ask, what role does OPEC play in influencing the prices of oil? Will emerging economies like India and China put further pressure on Oil prices? Answers to these questions can provide readers with most if not all of the significant aspect of oil market.

According to (Adelman, 2004) real problems of oil prices were faced after 1970 because of cartel behavior. OPEC cartel derived its power not only from geographic concentration of oil resources near the Persian Gulf, but also from the fact that exploration, production and development is in the hands of few state oil companies (Pirog, 2007). However, this view was opposed by some

researchers who through their empirical findings proved that OPEC does not behave as cartel. A.F. Alhajji, David Huettner (1998) in their study on OPEC and other commodity cartels: a comparison concluded that none of the characteristic of cartel behavior exists in OPEC; monitoring, quota system, punishment system, side payments, buffer stock, cartel authority. Cremer and Isfahani, (1991) in their study explained that the way oil prices behave and output of oil is unrelated to the way a commodity should behave in a cartel of monopolistic pattern. Many researchers who believe that OPEC is not a cartel argue that Saudi Arabia is a dominant producer among all the member countries that come under OPEC. Many studies were carried out explaining the same dominance of Saudi Arabia on other members including (Mabro (1975), Erickson (1980), Plaut (1981) and Singer (1983). Others believe that political factors increased oil prices and that prices were sustained because of the limited absorptive capacity of OPEC members. These studies include Ezzati (1976, 1978), Teece (1982) and Salehi-Isfahani (1987) among others. For some economists, the international oil market is competitive and speculation, panic and market inefficiency caused

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the oil crisis. Bohi and Toman (1993) believe that OPEC has not been elective in using its potential monopoly power. Hitherto, a rich body of literatures on oil market interaction can be found that are mainly involved with two aspects. One is to conduct empirical studies on interactions among diverse oil markets (Ewing, Malik and Ozfidan, 2002; Hammoudeh, Li and Jeon, 2003; Jiao, Fan, Wei, Han and Zhang, 2007; Jiao, Fan, Zhang and Wei, 2005; Lin and Tamvakis, 2001; Ng and Pirrong, 1996), and the other is concerned with the relationship between financial markets (especially the stock markets) and oil markets (Basher & Sadorsky, 2006; Chen, Roll and Ross, 1986; Faff and Brailsford, 1999; Hamao, 1988; Hammoudeh and Eleisa, 2004; Huang, Masulis, and Stoll, 1996; Papapetrou, 2001; Sadorsky, 1999, 2003).

Specific information flow of crude oil prices is very important to understand the dynamics of world crude market, especially for countries like India and China it is very important because both the countries are emerging nations and dependent more on oil producing countries. About 80% of oil requirements of China are met by importing oil from Middle East and Africa. India too is dependent on Middle East for its 70% of oil requirements. As per the latest statistics of EIA, China's oil consumption in total energy is stood at 20% and of India it is 31%, China is slowly reducing its dependency on imports of crude oil thus making it as a significant player in world crude oil market. A study done by K.C.Chen et al (2009) has discovered that although China emerges to be an important player it has little impact on the volatility of the world crude oil markets.

2. Research Questions

The purpose of this study is twofold one it gives an understanding of whether or not the selected OPEC and Non OPEC oil markets are integrated, if so what is the possible causal price relation running from each other markets, that is to determine the price movement from one market to the other market. Second it gives possible opportunities to explore for country like India to have strategic alliances with those which are causing price variations to developing nation like China, in other words India should move along the path of China to have strategic alliances with the other nations in exploration and production of oil. This study uses both causal (empirical) and descriptive research to find the answers to some of the questions: In a group of top oil producing and consuming

nations what price causal relations one would expect so that an oil dependent country can make strategic alliances with the nations causing price variations. What would be the role of China and US as the world top consumers in a group of oil dominant countries?

3. Data and Methodology

This study covers the period 2005 to 2015 of weekly price time series data (2005/02/29-2015/06/14) of selected countries of OPEC & Non OPEC countries taken from the EIA website published and authorized by Energy International Agency, USA. This time series data is analyzed by using the econometric techniques namely Johansen's rank procedure to test whether the selected international oil markets are co integrated or not, further VAR methodology is used to find the direction of causality and finally the same causal relationships are supported by applying causal data analysis TETRAD- IV software through Directed Acyclic Graph.

3.1 Non Stationary and Co integration

All the data variables in log level form and first difference of the log level variables are tested for stationary by using ADF (Unit Root Hypothesis) and KPSS statistics. All the data variables are converted into their log form to eliminate the scale effects and for the possible heteroskedasticity impact. The non stationary acts as a pre condition for the cointegration, therefore the dataset is tested for cointegration for possible long run relationships. In addition to the Engle-Granger causality technique, Johansen (1979) procedure of co-integration is also employed. Johansen's approach begins with an unrestricted VAR involving potentially non-stationary variables, which allows to deal with models having several endogenous variables.

3.2 Vector Auto Regression (VAR)

The VAR approach sidesteps the need for structural modeling by treating every variable as endogenous in the system as a function of the lagged values of all endogenous variables in the system. Vector Auto Regression (VAR) considers every variable as endogenous to model the dependent variable under study. VAR model frame work is defined by a function of current and lagged endogenous variables to model the dependent variable under study.

4. Empirical Analysis

All the price variables are found to be non-stationary in the level form, but all are integrated of order one. The ADF & KPSS test statistics used for testing the non-stationary of time series. The non-stationary acts as a pre-condition for the cointegration, therefore the dataset is tested for cointegration for possible long run relationships. Johansen's rank test for testing cointegration is useful whenever the dataset contains more than two endogenous variables. In this procedure after selecting the suitable lag length by using the appropriate information criterion by using Trace test and L Max test (Maximum Eigen value) that confirms whether the price variables are co integrated or not. After confirming the cointegration we use VAR calculations to determine the direction of causality.

4.1 Co integration of Oil Markets

Having found that all the variables in the study have unit roots that is, they are integrated of order one, our next step is to determine whether the price variables are co integrated or not, that is whether OPEC and Non OPEC have long term or equilibrium relationship between them or not. The time series graph of differenced variables shows expected co integration among the variables. Johansen's procedure of multivariate co-integration requires the existence of a sufficient number of time lags. The selection of lag length results are given in Table 1. Table 2 gives the results of Johansen's co-integration test. Both the Johansen trace tests and maximum eigenvalues support the rejection of the null hypothesis that there are no co-integrating relations in the system.

Table 1. Selection of Lag Length

Lags	loglik	p(LR)	AIC	BIC	HQC
1	16337.78069		-57.078591	-55.884419	-56.612553
2	16843.93024	0.00000	-58.356015	-56.059529*	-57.459787
3	17123.33662	0.00000	-58.833639*	-55.434839	57.507221*
4	17250.67487	0.00000	-58.774867	-54.273754	-57.018260
5	17377.76104	0.00000	-58.715206	-53.111780	-56.528410
6	17494.54434	0.00000	-58.619204	-51.913464	-56.002218
7	17624.65768	0.00000	-58.570221	-50.762167	-55.523046
8	17774.75126	0.00000	-58.591715	-49.681348	-55.114351
9	17893.16320	0.00000	-58.501457	-48.488777	-54.593904
10	18029.09049	0.00000	-58.472982	-47.357988	-54.135239
11	18137.78506	0.00008	-58.348448	-46.131141	-53.580515
12	18240.94514	0.00051	-58.204392	-44.884771	-53.006270
13	18394.63309	0.00000	-58.238565	-43.816630	-52.610253
14	18532.46887	0.00000	-58.216821	-42.692573	-52.158320
15	18662.64038	0.00000	-58.168044	-41.541482	-51.679353

Table 2. Co-integration Test (Johansen approach)

Co-integration rank Tests			
Unrestricted co-integration rank tests, Trace & Maximum Eigen (Lmax) value			
No. of co integrating Equations or Rank	Eigenvalues (λ_i)	Trace Test P-value	Lmax Test P-value
0	0.28906	922.45 [0.0000]	201.29 [0.0000]
1	0.25494	721.17 [0.0000]	173.63 [0.0000]
2	0.19667	547.54 [0.0000]	129.20 [0.0000]
3	0.16212	418.34 [0.0000]	104.36 [0.0000]
4	0.14226	13.98 [0.0000]	90.535 [0.0000]
5	0.11242	223.44 [0.0000]	70.359 [0.0000]
6	0.091082	153.08 [0.0000]	56.345 [0.0001]
7	0.053330	96.738 [0.0001]	32.335 [0.0729]
8	0.047396	64.403 [0.0005]	28.648 [0.0330]
9	0.031090	35.754 [0.0084]	18.634 [0.1099]
10	0.018895	17.120 [0.0265]	11.255 [0.1433]
11	0.0098914	5.8650 [0.0154]	5.8650 [0.0154]

*Both the Trace test and Lmax test indicates Eight co-integrating equations (Rank 8) at 5% level.

From the economic theory, the hypothesis is that price causal relations between the significant players of world oil market contributes in discovering price mechanism between the member countries and also paves way for strategic alliance with the other countries depending upon the market structure, exploration and production opportunities. Evidence of co-integration between oil markets suggest that the country which causing price variations (cause) to other markets have major role to play in significantly controlling the price of oil. The direction of causality determines the order of the world oil markets.

4.2 Direction of Casualty

The output of Directed Acyclic Graph (DAG) in Figure. 1 shows the direction of casual relationship among the tested variables. The bi-directional causality is clear between the OPEC member countries and between OPEC and Non OPEC member countries showing their impact on the world oil market. In OPEC, Saudi Arabia is the dominant player in controlling the price mechanism along with Iran. The US market still has its control on world oil market by strategic alliances in terms ruling the dollar currency, especially with the nations Mexico, Iran and Saudi Arabia. It is observed that though China acts as a price taker it is slowly making his position by significantly improving the strategic alliances in exploration and production opportunities. The causal relationship from China to Venezuela is shows this fact in this direction.

5. Conclusion

In this econometric study of updated time series data on crude oil prices taken from a total of twelve countries, Saudi Arabia, Iran, Iraq, Kuwait, Nigeria and Venezuela which are the OPEC countries representing Middle East, North Africa and South America and Non OPEC countries US, Canada and Mexico representing North America, Malaysia and China representing Asia.

All the data variables ADF tests concludes the stationary after first differencing and the dataset is tested for possible cointegration. The selection of lag length based on AIC criterion is selected as 3 and Johansen's rank test by using the Lmax and Trace test found the rank as 8 that confirms the cointegration which implies that the selected international oil markets are integrated. Further the VAR results showed the direction of causality and the same is confirmed by the TETRAD software DAG graph.

From the Directed Acyclic Graphs, the flow of casual relations are very much clear between the selected OPEC countries where as there is no much price casual movement between the non OPEC member countries. This study reiterates the position of China in world oil markets, and it is observed that though China acts as a price taker it is slowly making his position by significantly improving the strategic alliances in exploration and production opportunities. The causal relationship from China to Venezuela is shows this fact in this direction.

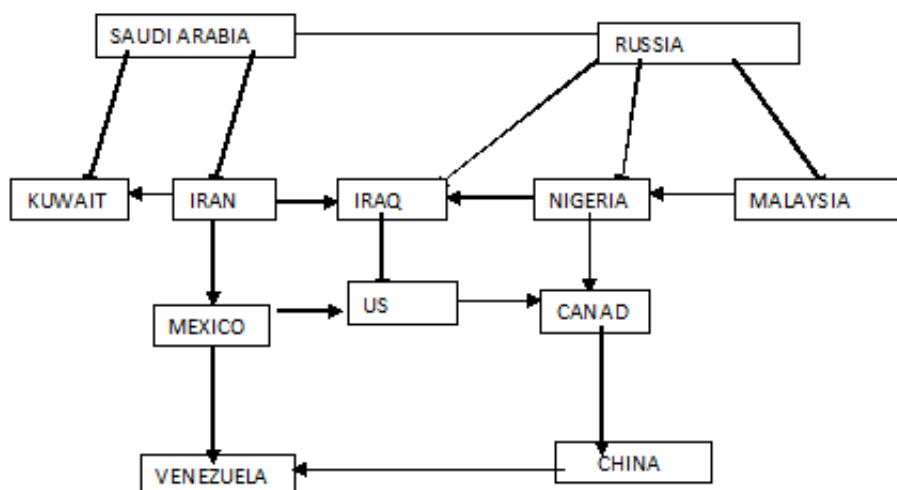


Figure 1. Directed Acyclic Graph showing causal flow of price information.

Assuming the *Ceteris Paribus* a developing country like India can also join hands with the countries in the path of China. The recent accord between India and Venezuela in exploration and production of oil and gas is a welcome step in this direction. In this study the subjective selection of OPEC & Non OPEC countries can accommodate a true picture of causal relationships in a group of oil dominant countries.

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