

Cluster Analysis of Crude Oil Production: Is OPEC monthly production really that different from non-OPEC production?

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Keywords

Crude oil production, OPEC, non-OPEC, cluster analysis

Overview

Much has been said about the ability of OPEC to manipulate crude oil prices. Yet, OPEC producers can only affect prices through coordinated changes in their production levels. If this takes place then it is expected that there would be some variation in the way production changes through time, with OPEC production changes differing from non-OPEC production changes for example. I explore the possibility of production clustering across crude oil producing nations using EIA monthly crude oil production data for 20 crude oil producing nations. This group includes the 12 key OPEC members (Algeria, Angola, Ecuador, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, Venezuela) as well as the major non-OPEC crude oil producing nations (Canada, China, Egypt, Russia, Mexico, Norway, UK, US). I find considerable evidence of dissimilarity in country production for the full period and for the first half of the study period through to 1990, but there is little evidence of OPEC based clustering in the subsequent period from 1990 to 2010 with virtually all of the crude oil producers falling within one cluster during this period. It would appear that the OPEC attitude to price manipulation changed dramatically around 1990.

Method

I use cluster analysis to identify natural links that exist between the 20 crude oil producing nation monthly percentage change in production reported by the US Energy Information Administration (EIA) over the period from January 1973 through to October 2010. The analysis is conducted for the full sample as well as for the two sub-periods, January 1973 to June 1990 and February 1991 to October 2010. The break point is chosen to avoid the period surrounding the invasion of Kuwait by Iraq in August 1990 and the liberation of Kuwait in February 1991 though we do not propose that this event fully explains the results reported in this paper.

Cluster analysis is used to identify whether there are groups of firms with similar production rates over the selected study periods. Clustering is expected where groups of producers act in a similar way over time. For example, US and Russian production rates might be quite similar over time because these producers determine their optimum production rate and tend to maintain this over time (Adelman and Watkins 1995). The member nations of OPEC provide a more complex story because, where OPEC decides on a particular production level there is incentive for some members of the cartel to cheat. In this case, larger producers in the cartel (say Iran, Saudi Arabia or Venezuela) could adjust their production rates to penalise cheating and thus ensure that the agreed upon OPEC production level is maintained. It is unlikely that the nations that make up OPEC will be allocated to one or more cluster. It is more likely that the OPEC member nations will be allocated to different clusters that best describe their optimum production rates (Adelman 1979) though this is an empirical issue.

Cluster analysis is a classification technique. While traditional classification techniques focus on assigning new observations to established groups, cluster analysis is an inductive approach that relies on the nature of the data in identifying the existence or otherwise of clusters. There are different methods used in cluster analysis for computing similarity measures between objects (Clatworthy, Buick et al. 2005). I use SPSS to perform the cluster analysis, choosing the squared Euclidean distance approach, between groups linkage and the hierarchical agglomeration algorithm.

While correlation analysis could be used to identify the linkages that exist among the crude oil production rates of different nations, cluster analysis considers national crude oil production rates simultaneously across the various nations in the sample rather than rely on the pair by pair comparison that is a characteristic of correlation analysis. Thus cluster analysis provides a measure of commonality in crude oil production decisions in multi-dimensional space.

In this approach the most similar cases are sequentially merged. These final clusters are represented visually with a tree diagram or dendrogram, though I do not report these results in this paper due to space limitations. The dendrogram underlies the discussion that follows as it provides a hierarchical representation of the relations between the national crude oil production rates. The Dendrogram is a tree diagram with the branches in the tree representing clusters. The branches merge at nodes whose positions along a distance (or similarity) axis indicate the level at which clustering takes place and thus can identify the natural groupings of crude oil producing nations according to the changes in their monthly crude oil production rates.

Results

Cluster analysis is conducted for both the full period, January 1973 through to October 2011, and for the two sub-periods, January 1973 to June 1990 and February 1991 to October 2010. Three relatively small clusters of crude oil producing nations are identified for the full period and the first sub-period, while two clusters are identified for the second sub-period. The clusters identified in the second sub-period are quite different from those identified in the first sub-period and for the full period.

For the full period, the closest group or cluster of countries by rate of change in monthly production consists of Angola, Algeria, China, Mexico, Russia and the USA. It would appear that these countries adopt similar production strategies over the sample period. The second cluster includes Canada, United Arab Emirates, Libya and Saudi Arabia. The third cluster includes Nigeria and Venezuela. The remaining crude oil producing countries could not be allocated to a particular cluster because of a lack of similarity in their production rates with other nations in the sample.

The clusters in the first sub-period are similar to those reported for the full period, though there are some important differences. The first cluster containing those nations with most closely matched rates of change in monthly production includes China, Mexico, Russia, USA and Venezuela. The second cluster includes Angola, Algeria, Canada and the United Arab Emirates. The last of the clusters includes Libya and Saudi Arabia. As with the full period analysis, the remaining crude oil producing countries could not be allocated to a particular cluster. Some of the key OPEC nations fall naturally into one of three clusters: Venezuela in the first cluster; Angola, Algeria and the United Arab Emirates in the second cluster and; Libya and Saudi Arabia in the third cluster. There are other members of OPEC that could not be allocated though this is probably not surprising given that these are the smaller members of OPEC, most likely to benefit from cheating within the cartel.

The cluster analysis for the second sub-sample is quite different from the previous with all crude oil producing nations falling within one of two clusters, with the exception of Iraq and Venezuela. The first cluster includes virtually all of the oil producing nations including the OPEC nations, Algeria, Angola, Ecuador, Iran, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and the non-OPEC nations, Canada, China, Egypt, Russia, Mexico, US. The second cluster for this period includes Kuwait, Norway and the UK. Venezuela and Iraq could not be allocated to particular cluster. It would appear that over the last 20 years the crude oil producing nations have stabilized their production with similar production rates evident across 15 of the 20 crude oil producing nations included in this study. With the exception of Venezuela, Iraq and Kuwait, OPEC nation production rates are similar to those of the non-OPEC nations from the early 1990s onwards.

Conclusions

The results of this data driven analysis highlight the dramatic changes that have occurred within the crude oil producing nations over the period from 1973 to the present. While the full sample and the first sub-period suggest that OPEC has played an active role in the crude oil production, the second sub-period analysis covering the 1991 to 2010 period suggests that the OPEC members behave in the same manner as non-OPEC producers, with just one cluster accounting for virtually all of the crude oil producing nations. The exceptions include Iraq, which faced sanctions and was eventually invaded during the study period, and Venezuela, which is generally more closely related with the US and Russia in this study than with OPEC.

References

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