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Does OPEC Matter After 9/11?

OPEC Announcements and Oil Price Stability

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Abstract

This study examines the effects of OPEC announcements on oil prices and volatility in both crude oil spot and futures markets. We study daily OPEC meeting announcements since 1990 on changes in oil supply by member countries and empirically test whether OPEC actions have been able to reduce oil price volatility as the cartel suggests it does. Our findings indicate that OPEC production cut announcements contribute to a lower volatility in spot and futures price changes. However, we find that September 11 attacks have lead to a structural change in both the mean and volatility of price changes. Interestingly, our findings for the post-September 11 period indicate that only non-OPEC related announcements have significant effects, whereas OPEC announcements do not seem to affect either the mean or conditional volatility of price changes in both spot and futures markets.

Keywords: Crude Oil Price, OPEC, Non-OPEC, Futures Markets

1. Introduction

… Let's be clear about what's at stake. If OPEC disappeared tomorrow, oil prices would drop to somewhere around $8 a barrel and gasoline prices would almost certainly be south of $1 a gallon. A price collapse of that magnitude would do more for consumer welfare and the overall health of the American economy than almost anything that's been put on the table by President Bush or his Democratic Party rivals. Accordingly, the OPEC cartel should be resisted not embraced, and policy should aim at undermining it, not propping it up.

Jerry Taylor, director of natural resource studies at the Cato Institute in "OPEC is the problem," (March 26, 2004). The article originally appeared on *National Review Online*.

Price of crude oil has experienced a sharp increase during late 2000, triggering a heated discussion on whether the Organization of Petroleum Exporting Countries (OPEC) is really a price stabilizing factor in the world oil market. There is no doubt that OPEC is a major player in the oil market. OPEC member countries (Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, UAE, and Venezuela) produce about 40 percent of the world's crude oil (Figure 1) and 16 percent of its natural gas.[1] Furthermore, the fact that OPEC exports represent more than half of the oil traded internationally gives OPEC a strong influence on the world oil market.

OPEC defines its principal objective as to ensure price stability in oil markets by eliminating harmful and unnecessary fluctuations.[2] Although OPEC does not directly determine the price of oil, as the market forces of supply and demand set the prices, OPEC controls the supply of oil to the market in order to achieve a certain price band that its members agree upon. Therefore, by controlling the amount of crude oil they export, OPEC seeks to keep the oil price within a certain band reducing uncertainty about oil prices.

In a perfect world where OPEC's actions actually help stabilize oil prices and therefore reduce uncertainty about future oil prices, one would have no reason to question the need for this organization. The world needs oil and rising oil prices can have significant inflationary effects as

[1] Energy Information Administration, www.eia.doe.gov.
[2] OPEC's official website, http://www.opec.org

higher cost of energy can slow economic growth forcing consumers to spend less on non-energy related goods and companies to reflect high energy costs on their products. Stability in energy costs helps governments (and corporations alike) plan its economic activities and manage its resources more effectively. Recent economic and political developments in the world arena have substantially affected the stability of oil markets. Several factors, among others, include higher demand for oil from the fast-growing economies of China and India; supply disruptions in Iraq, Nigeria, Venezuela, Russia and the U.S. Gulf Coast; fear that the global oil industry was finding less and less new oil; and finally terrorist and military attacks. However, the inability of OPEC to prevent the recent steep rise and excessive price fluctuations in oil prices calls into question the effectiveness of OPEC as a stabilizing force in the oil market.

OPEC's critics argue that the very purpose of the cartel (as they call it) is to increase oil prices by restraining production. Furthermore, the potential clash between "hawks" in OPEC like Nigeria and Iran with large populations and few other resources pushing for higher prices and other OPEC members like Kuwait and Saudi Arabia resisting the hawks, creates an uncertain environment for outsiders watching oil price movements. The uncertainty in OPEC's behavior and its members' fidelity to its promises on sticking to the agreed quotas invite speculation, further increasing volatility in oil prices. Defenders of OPEC, including policy makers in Washington, however argue that the cartel actually helps stabilize oil prices by increasing the oil supply to the market preventing further spikes during crisis periods. They further argue that restrictions on oil supply set by OPEC does us a favor by postponing the end of the oil age. Whatever the argument may be, whether OPEC is a friend or an enemy depends on its effectiveness as a stabilizing force in the oil market, i.e. eliminating excessive fluctuations in prices. In order to answer this question, one needs to assess OPEC's influence as a major force driving the crude oil market. Therefore, this paper aims to provide an insight to how effective

OPEC actions have been in affecting oil prices and whether they have calming effects on the volatility of oil returns, especially after the September 11 attacks.

The goal of this study is to examine the effects of OPEC's actions on oil price changes and the volatility of returns pre- and post-September 11 periods. More specifically, we study daily OPEC meeting announcements between 1990 and 2006 on changes in oil supply by member countries and empirically test whether OPEC actions have been able to reduce oil price volatility in the spot market as the cartel suggests it does. Furthermore, we use a comprehensive daily data set on production announcements by non-OPEC oil producers like Russia and North Sea countries and test if non-OPEC's actions have significant effects on the volatility of spot oil prices.

The second contribution of this study is to extend the analysis to oil futures by analyzing the impact of OPEC and non-OPEC announcements on returns and volatility in futures markets. This is an issue of high interest to risk managers and corporations whose profits depend on how energy costs might change over their investment horizon. Identification of the factors that affect the pattern of futures prices is especially of great importance to risk managers as the effectiveness of their hedging strategies depend on how futures prices move during the investment horizon.

Our empirical analysis of daily oil spot and futures price changes for the period 1990 through 2006 indicate that production announcements by OPEC as well as non-OPEC oil producers have a significant effect on both the conditional mean and conditional volatility of returns in spot and futures markets. In line with theory, production cuts (increases) lead to higher (lower) prices with both OPEC and non-OPEC announcements. However, regarding the conditional volatility of price changes, although we find a positive and significant time trend in

the conditional volatility of price changes, we find that production cut announcements in general seem to have a negative effect on the conditional volatility term, having calming effects. This can be due to either information arrival to the market, so that the announcement leads to lower trading volume or some kind of a herd behavior in the market leading investors to behave similarly, reducing overall volatility.

We also find that the September 11 attacks have lead to a structural change in both the mean and volatility of price changes, affecting both terms positively, i.e. leading to higher prices and higher volatility. However, our findings for the post-September 11 period indicate that only non-OPEC related announcements have significant effects, whereas OPEC announcements do not seem to affect either the mean or conditional volatility of price changes in both spot and futures markets. We find that production cut news from non-OPEC producers lead to lower volatility in all three series during the post September 11 period. An examination of how trading volume changes around announcement dates suggests that these production cut announcements lead to lower trading volume during the post-September 11 period. This is in contrast with higher trading volume during the pre-September 11 period. Therefore, we conclude that production cut announcements lead the market to a 'wait and see' position, leading to lower trading volume and thus lower volatility. Our findings indicate that OPEC announcements did not have any significant impact on the returns and the volatility of oil prices, during the post-September 11 era.

The remainder of the paper is organized as follows. Following a literature review in Section 2, we describe the data in Section 3. We explain the model and report our main results in Section 4. Following a discussion of how announcements affect trading volume in Section 5, we conclude with a summary and implications for future research.

2. Literature Review

Many aspects of oil markets have been examined from different angles. A small subset of the studies in the literature has specifically concentrated on the relation between OPEC actions and energy prices. Draper (1984) examines the behavior of heating oil futures prices around OPEC meetings and concludes that the market has been efficient in the sense that investors have correctly anticipated meeting results and reflected their expectations on oil prices even before the meeting took place. However, Deaves and Krinsky (1992) suggest the opposite and find that investors systematically underreacted to OPEC conferences that conveyed bullish news, leading to abnormal profits for certain investors. Gülen (1996) examines whether OPEC is an effective cartel acting to share the market by controlling output and influencing oil prices. He finds that the period from 1982 to 1993 is the only period in which the causality from OPEC production to the price of oil is statistically significant. In a related study, Alhajji and Huettner (2000) find that neither OPEC nor the OPEC core can be characterized as a dominant producer in the world crude oil market for the period 1973 to 1994. Kohl (2002) argues that OPEC faces difficulties to stabilize oil price with imperfect data and very limited instruments. He suggests that OPEC's use of production quotas as the only instrument to stabilize prices has not been as effective due to a number of factors including geo-political unrests, changes in demand, changes in Iraqi exports, shifting economic conditions, and production of non-OPEC countries.

Regarding the relationship between the volatility of price changes in the oil market and OPEC announcements, which is the subject of this paper as well, Wilson and Aggarwal (1996) examine the extent of sudden changes in variance in three series including the 1-month oil futures return series, a series constructed from the returns of oil-producing companies, and an S&P 500 return series. They find that the oil futures series is susceptible to sudden volatility

changes during key time periods during the 1980s and 1990s. In a simulation study, Yang, Hwang and Huang (2002) construct a model of oil price volatility under a scenario where OPEC cuts oil supply to the market and conclude that non-OPEC or domestic production is a significant factor that limits the magnitude of price hike, thereby stabilizing the market. In a more related article, Horan, Peterson, and Mahar (2004) examine implied volatility from options on crude oil futures surrounding OPEC meetings. They find that highly visible bi-annual conferences are associated with a drop in volatility. Furthermore, the most pronounced decline in volatility coincides with the meetings of the Ministerial Monitoring Committee, which makes production recommendations to the larger conference.

In addition to OPEC and non-OPEC studies, some have investigated the impact of key events on oil market volatility. In a test of the Enron effect on the volatilities of energy prices, Pindyck (2004) examines the behavior of natural gas and crude oil price volatility in the United States since 1990 and finds a statistically significant positive time trend in volatility. However, he concludes that the increases in volatility of these commodities are too small to have economic significance. More recently, Kaufmann (2006) uses causality analysis to examine the factors that affect changes in real oil prices. His analysis suggests that there is a statistically significant relation among oil prices, OPEC capacity utilization, OPEC quotas, the degree to which OPEC exceeds these production quotas, and OECD stocks of crude oil. He finally concludes that OPEC plays an important role in determining real oil prices.

In short, the literature presents a conflicting picture on the significance of OPEC announcements on oil price changes. Our study extends the literature by testing the effects of both OPEC and non-OPEC announcements on the conditional mean level and volatility of returns in cash and futures markets. Previous studies do not control for the effects of non-OPEC news in testing the ability of OPEC actions to move oil prices, which may bias the results. In

addition, traders may have different expectations about the future of oil markets and read OPEC announcements differently since the September 11 attacks and the consequent invasion of Iraq. Our model also tests the effects of OPEC and non-OPEC announcements during the post-September 11 period as well.

3. Data, Sample Period and Descriptive Statistics

We use daily spot and futures prices for the period January 1, 1990 through February 27, 2006. Spot prices can be measured using cash prices or using the price for the nearest futures contract. In this study, we measure spot prices by cash prices, hoping that cash prices will better reflect actual transactions. Figure 2 plots the daily nominal spot prices during from 1990 to 2006. However, it is also interesting to examine how expectations of future oil prices are affected by OPEC announcements. Therefore, in addition to cash prices, we also compiled daily NYMEX light sweet crude oil futures settlement prices for the second and third closest contracts, which are two of the most liquid contracts with largest trading volume. Futures prices are constructed with contract rollover occurring about one week before maturity in most cases.

Table 1 presents several summary statistics for daily cash price as well as futures price changes for the second and third closest contracts (Future2 and Future3). Examining the full period of study, we observe that cash price changes have been the most volatile (2.513%) with lower volatility values for longer maturities. However, the reverse order holds for mean returns. Correlations between spot and futures returns is high around 0.83 indicating common risk factors affecting cash prices as well as future price expectations for crude oil. As will be discussed later on, we find a significant structural change in the means and volatilities of returns after September 11 attacks. Examining Panel C of Table 1, we observe a general upward trend in the means, volatilities and correlations. Mean returns range between a low of 0.05% for spot returns and a high of 0.13% for the third-nearest contract, whereas spot returns still have the highest volatility

with 2.384%. Correlations in the post-September 11 period range around 0.89 indicating that the market has become riskier, yet more correlated.

Regarding OPEC announcements on production decisions, we examined meeting summaries from the Official Resolutions and Press Releases published by the OPEC Secretariat. OPEC meets twice a year on prescheduled dates for 'ordinary' conferences but they also call for 'extraordinary' conferences with short notice. The ministerial meetings are held occasionally to resolve operational and monitoring problems in the organization; and sometimes they decide to change production levels. Having compiled a list of meetings, we then classified each OPEC announcement in terms of a production cut, hike and no change in production levels. As reported in Table 2, a total of 62 OPEC meetings took place during the period studied, of which 19 resulted in a production hike, 17 in a production cut, and 26 in no change in production levels. The distribution of announcements during the pre- and post-September 11 periods do not show significantly different patterns.

Non-OPEC countries including Russia, Mexico, China, Canada, Angola and North Sea countries Norway and the U.K., among others, currently produce about 60 percent of the world's oil (Figure 1). It is only natural to assume that supply related news from these nations would have an impact world oil prices. For this purpose, in addition to OPEC announcements, oil supply related news by non-OPEC countries were compiled from the Energy Information Administration's website.[3] Several examples of such events include the opening of a new oil pipeline from the Tengiz field in Kazakhstan to the Russian port of Novorossiysk; announcement of export cuts (or hikes); or a strike at one of Angola's offshore oil projects shutting production at that facility. Considering the fact that the U.S. is the largest consumer (as well as importer) of crude oil in the world (20.7 million barrels per day as of 2005), we also included in our analysis

[3] www.eia.doe.gov

the U.S. government's announcements on releases of crude oil from the Strategic Petroleum Reserve. Once again, as reported in Table 2, we compiled 91 events directly related to crude oil supply to the market, of which 55 lead to supply hikes and 36 led to supply cuts. Please note that only events directly related to oil supply are considered in the analysis, which means that announcements that are not directly related to current oil supply are ignored. As an example, we ignore an announcement such as the start of construction by Exxon Mobil of a new offshore development project in Angolan waters. We observe that there are 33 production hike and 30 cut announcements during the post-September 11 period, indicating a significant increase in non-OPEC announcements.

4. Model Specification and Estimation

4.1 Model Specification

Our goal is to test for changes in means and volatilities of return series due to announcements from OPEC and non-OPEC oil producers. For this purpose we construct a GARCH model of returns similar to the model suggested by Pindyck (2004). Pindyck (2004) estimates a GARCH model of natural gas and crude oil price changes and tests for an ENRON effect in mean and conditional volatility terms for these commodities.

Let S_t and F_t be the logarithmic spot and futures prices on day t. As mentioned earlier, we construct two futures series, Future2 and Future3, for the second closest and third closest contracts respectively. The following GARCH model is then estimated to identify variations in the means (i.e., returns) as well as conditional volatility of returns.

$$S_t - S_{t-1} = a_0 + a_1 \mathbf{s}_t + a_2\, TBILL_t + a_3\, OPEC\_UP_t + a_4\, OPEC\_DN_t + a_5\, OPEC\_UC_t + a_6 NOPEC\_UP_t + a_7\, NOPEC\_DN_t + a_8\, TIME_t + a_9\, SEP11_t + \varepsilon_t. \quad (1)$$

where

s : The standard deviation of oil price changes (GARCH term in the mean-equation), capturing the impact of the changes in the conditional volatility on mean returns.

TBILL: The Treasury bill rate (specified as a daily rate) is used in the model as the interest rate is a large component of the carrying cost of holding the commodity.

TIME: This is a trend variable that is advanced by one each day. This variable is included in the equation to test for any systematic time variation in the moments of return series.

SEP11: This variable tests for a structural change due to September 11 attacks. The market reopen on September 17, therefore SEP11 is a dummy variable equal to unity beginning with September 18, 2001, when the first price change is available, and zero before.

OPEC announcements: OPEC dummies represent OPEC announcements on production decisions. However, we assume that there would be some form of an information leakage before the official announcement is made. Therefore, these variables take into consideration both the official announcement day and the day preceding the official announcement.

OPEC_UP (OPEC_DN, OPEC_UC): A dummy variable equal to unity on the announcement date and the day preceding it given that the announcement is a production hike (cut, no change).

Non-OPEC announcement: Similarly, a second set of dummy variables 'NOPEC' is employed to represent events that affect oil supply from non-OPEC oil producing nations. However, unlike OPEC announcements, these announcements do not become public information in a structured and predictable format on pre-specified dates. Therefore, these variables consider only the official announcement date.

NOPEC_UP (NOPEC_DN): A dummy variable equal to unity on the announcement date given that the announcement is a production hike (cut).

The second equation explains the variance of the error term as a GARCH (p, q) process:

$$\mathbf{s}_t^2 = \alpha_0 + \sum_{j=1}^{p} \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \gamma_1 \text{OPEC\_UP}_t + \gamma_2 \text{OPEC\_DN}_t + \gamma_3 \text{OPEC\_UC}_t$$

$$+ \gamma_4 \text{NOPEC\_UP}_t + \gamma_5 \text{NOPEC\_DN}_t + \gamma_6 \text{TIME}_t + \gamma_7 \text{SEP11}_t. \qquad (2)$$

Equation 2 contains both the time trend and SEP11 dummy to test for time variation in volatility as well as the September 11 effect, respectively. A similar model is applied to gold futures by Melvin and Sultan (1990) in order to explain the impact of South African political unrest on the volatility in the gold market. Pindyck (2004) utilizes a similar model to test the impact of the ENRON scandal on the volatility of natural gas and crude oil price changes.

4.1 Full Period Findings and the September 11 Effect

Table 3 shows maximum likelihood estimates of the model for spot as well as futures price changes.[4] In all cases, following Pindyck (2004) the number of lags in equation (2) is chosen based on the Akaike information criteria as well as ensuring no serial correlation in returns and no remaining ARCH effects in volatility. The first thing that we observe in the table is the positive marginal contribution of September 11 on conditional volatilities of all three return series, with the highest effect on spot returns. For spot returns, the estimated coefficient is $5x10^{-5}$ which corresponds to a standard deviation of 0.7%. The contribution of September 11 period on volatility represents roughly 28 percent of the observed volatility of spot returns (2.513%). Although we observe a positive effect on conditional volatilities, we find that only futures mean returns are significantly affected by September 11 with the effect becoming smaller for longer maturities. Considering mean return of 0.058% for Future2, the marginal contribution of September 11 period of 0.004% represents about 7% increase in mean returns. Hence, we

[4] We use the Bollerslev-Wooldrige standard errors in all estimations to deal with the non-normality of returns in spot and futures returns.

conclude that September 11 had a significant impact, causing higher volatility (risk) and hence compensation in the futures market.

Regarding the effect of announcements, we find similar patterns for all three series. As expected, production hike (cut) decisions lead to lower (higher) prices. For example, production hike decisions by OPEC lead to a 1.31%, 1.05%, and 0.96% drop in cash, future2 and future3 prices, respectively. Considering the magnitude of mean returns for these series in Table 1, the marginal contributions of OPEC announcements are highly significant. Note that the magnitude of the effects decrease as we move from cash prices towards futures prices with longer maturities, indicating that OPEC actions affects the spot market more significantly than it does futures markets. Similar conclusions can be made for non-OPEC related announcements. However, the magnitude of non-OPEC announcements on mean returns is lower than those for OPEC announcements, suggesting that OPEC announcements have larger wealth effects. For example, production cut announcement by OPEC leads to a price increase of 1.24% whereas the same type of news from a non-OPEC producer leads to a 0.7% price increase. Once again, the effect of non-OPEC announcements decreases as we move towards longer maturities for futures price series. Interestingly, announcements of no changes in production levels do not seem to have any effects on means returns or volatilities, indicating no surprise information.

Regarding conditional volatilities, once again we find similar results for all three series. Production cut announcements from both OPEC and non-OPEC sources lead to lower conditional volatilities, although non-OPEC production cuts do not seem to affect volatilities of futures price changes. The findings suggest that both OPEC and non-OPEC actions affect spot volatility, but futures market volatility is more sensitive to OPEC announcements. This finding is consistent with Horan, Peterson, and Mahar (2004) who find a drop in the estimated implied volatilities from options on crude oil futures surrounding OPEC meetings. One explanation for

this finding can be due to information arrival to the market and reduced uncertainty as a result of it. However, the fact this drop in volatility is observed only with production cuts might also suggest a herding behavior by investor leading to lower variability in returns. Several studies including Christie and Huang (1995), Chang, Chen, and Khorana (2000) among others, have suggested that herd behavior is more likely to occur during periods of market stress and this may be one reason why we observe asymmetric behavior in volatility only with production cuts leading to a tighter market.

4.2 Pre- and Post-September 11 Findings

Having found a structural change in the means and conditional volatilities due to September 11, we then split the sample into pre- and post-September 11 periods. Although we included a dummy variable for September 11 in the full sample results, it may not capture the full effects of September 11 because it accounts for a constant shift only; it is possible that slope coefficients have also changed since then. In addition, because the pre- September 11 period runs until September 10, 2001, the day before the attacks and the post -September 11 period starts with September 18, 2001, the longer pre-September 11 period may dominate the results and hence does not capture the changes in trader behavior since September 11. Tables 4 and 5 therefore report the maximum likelihood estimates for the two sub periods as well.

A comparison of the pre- and post-September 11 periods reveals a striking difference, indicating slope changes. We now find that none of the OPEC announcements are significant during the post-September 11 period, neither in the mean nor in the conditional volatility equations. We find that prices are most sensitive to production hike decisions from non-OPEC producers with the marginal effects of -0.75%, -0.6% and -0.51% on cash, future2 and future3 series, respectively. Spot prices are also found to be sensitive to production cut announcements from non-OPEC countries. Overall, during the post- September 11 period, traders seem to react

to non-OPEC announcements only. There is also an asymmetric effect in that only production cut news signals new information to the market.

Regarding conditional volatilities, once again we find that non-OPEC related news is the only significant factor, leading to lower volatility in all three series, indicating calming effects associated with new information arrival. The highest effect seems to be on cash price changes with the effect going down as the maturity gets longer. The estimated marginal effect on volatility of a production cut announcement from a non-OPEC supplier is 2.12×10^{-4}, which is about 1.45%. Considering mean volatility of spot returns of 2.384% during this period, this marginal contribution corresponds to almost 60%, which is economically very significant.

The finding that non-OPEC related news is the only significant factor affecting both conditional mean return and volatilities may be due to several reasons. One reason might be the significant increase in commercial oil stocks in developed nations to cover for unexpected supply disruptions due to geopolitical developments such as September 11 attacks or the invasion of Iraq, etc., and/or OPEC production cuts. Figure 3 plots commercial petroleum stocks in U.S., Japan, and Europe since 1987 and shows a sharp upward trend since the end of 2001, where our second period starts. In fact, an argument put forward recently is that OPEC has become obsessed with the amount of crude held in commercial inventories in the U.S. and other major industrialized countries (Wall Street Journal, Dec. 8, 2006). These inventories are sufficient for a total of 55 days of demand as of September 2006 according to the International Energy Agency. Another reason may be due to an increasing list of alternative suppliers of crude oil like Brazil, Angola, Central Asian nations, and increased output from Russia. As Table 2 shows, there was a significant increase in the number of non-OPEC announcements during the post-September 11 period. Whatever the reason might be, our findings suggest that OPEC announcements did not have much influence on the crude oil market after September 11.

Another interesting finding is that the term $\mathbf{s}_t$, i.e. the standard deviation of the error term ε_t, are found to be significant and negative for futures returns. Normally, we would expect a positive relation between the return on the commodity and its riskiness represented by the term $\mathbf{s}_t$. However, we find the opposite result for futures price changes. One reason why the positive relation between risk and return does not hold in this case might be due to speculative activities, especially during the post-September 11 period. As speculators do not actually intend to deliver or gain ownership of crude oil, this finding is not surprising. A similar argument can also be made for our findings on TBILL. Once again, we would expect a positive relation between the risk free rate and futures prices as the risk free rate is an important part of carrying costs for a storable commodity such as crude oil. However, once again we find that the estimated coefficients for TBILL are significant and negative. This can again be due to the effects of speculator activity in the futures market as these speculators almost never intend to actually deliver or hold the underlying asset.[5] Finally, our results put a serious doubt on the effectiveness of OPEC to influence oil markets, especially during the post September 11 period.

5 Announcements and Trading Volume

Having found significant negative marginal effects of non-OPEC production cut announcements on volatility, a natural question that comes to mind is whether trading volume has anything to do with this finding. For this purpose, we regressed the log of daily total futures trading volume on our announcement variable, and some additional variables intended to capture persistence in volume. [6] We estimate the following model:

[5] Pindyck (2004) reports similar results in the mean equation for natural gas and crude oil prices.

[6] Flannery and Protopapadakis (2002) propose a similar model to estimate the effect of macroeconomic factors on aggregate stock returns.

$$\log(volume_t) = \alpha_0 + \sum_{k=1}^{18} \theta_k \log(volume_{t-k}) + \alpha_1 \text{OPEC\_UP}_t + \alpha_2 \text{OPEC\_DN}_t + \alpha_3 \text{OPEC\_UC}_t$$

$$+ \alpha_4 \text{NOPEC\_UP}_t + \alpha_5 \text{NOPEC\_DN}_t + \alpha_6 \text{TIME}_t + \alpha_7 \text{SEP11}_t + e_t. \quad (3)$$

Estimation results using OLS are reported in Table 6.[7] Interestingly, production cut announcements by non-OPEC producers seem to have opposite marginal effects on trading volume during the pre- and post-September 11 periods. These announcements increase trading volume in futures markets during the pre-September 11 period, whereas they lead to lower trading volume during the post-September 11 period. Interestingly, these announcements are found to be the only ones that lower volatility during the post-September 11 period. Our interpretation of these results is that announcements from non-OPEC producers are the main driving forces in the crude oil market, making OPEC less influential, especially after September 11. More specifically, production cut announcements from non-OPEC producers seem to lead the market to take a 'wait and see' position, resulting in lower trading volume and lower volatility. This is consistent with evidence in Table 5 that production cut announcements from non-OPEC producers reduce volatility significantly. This may also explain the significant but negative coefficient in the same table for the standard deviation in the mean equation for futures during the post-September period only. In addition, we find that production hikes by OPEC also lead to higher trading volume in all three periods; however, as Table 5 suggests, we find that these announcements, unlike non-OPEC, do not necessarily lead to a significant effect on mean returns and volatilities.

6. Conclusion

In this study, we use a comprehensive set of news and announcements on crude oil supply from both OPEC and non-OPEC oil producers between 1990 and 2006 and empirically test whether OPEC actions have been able to reduce oil price volatility as the cartel suggests it

[7] Estimating Equation (3) using GARCH models produced qualitatively similar results.

does. Our analysis of oil cash and futures price changes for the period 1990 through 2006 indicate that production announcements by OPEC as well as non-OPEC oil producers have a significant effect on both the mean and conditional volatility of returns in spot and futures markets during the full period. Regarding the conditional volatility of price changes, although we find a positive and significant time trend in the conditional volatility of price changes, consistent with Horan, Peterson, and Mahar (2004), we find that production cut announcements in general lead to lower volatility.

However, our findings for the post-September 11 period indicate that only non-OPEC related announcements have had significant effects whereas OPEC announcements do not seem to affect either the mean or conditional volatility of price changes in cash and futures markets. We find that production cut announcements from non-OPEC producers lead to lower volatility in all three series during the post September 11 period. An examination of how trading volume changes around announcement dates suggests that these production cut announcements lead to lower trading volume during the post-September 11 period. This is in contrast with higher trading volume during the pre-September 11 period. Therefore, we conclude that production cut announcements from non-OPEC producers lead the market to take a 'wait and see' position, resulting in lower trading volume and thus lower volatility. We conclude that announcements from non-OPEC producers have been the main driving forces in the crude oil market, making OPEC less influential, especially after the September 11 attacks. We have provided several reasons for the change in OPEC's influence over time. A more detailed, empirical investigation is necessary to better understand the forces behind this. We leave this to further research.

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Figure 1: World Crude Oil Production, 1973-2004

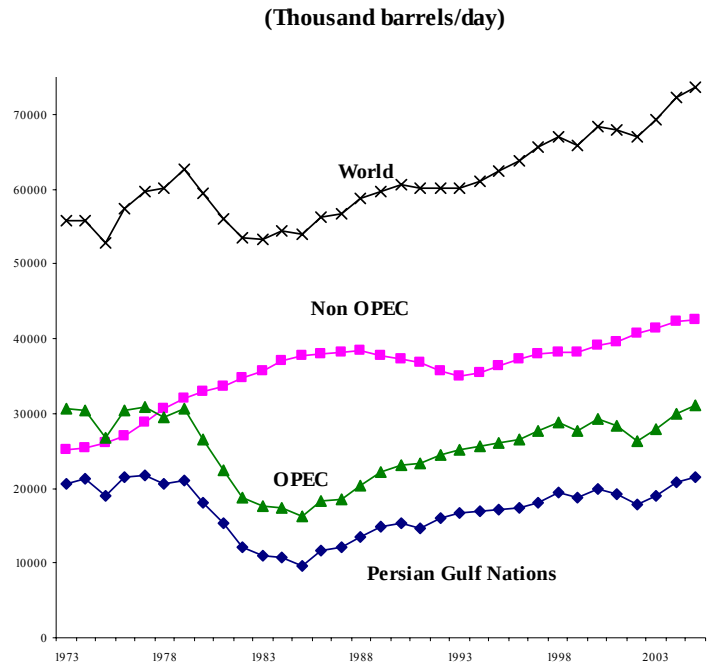

Figure 2: Crude Oil Spot Prices (Nominal), 1990 - 2006

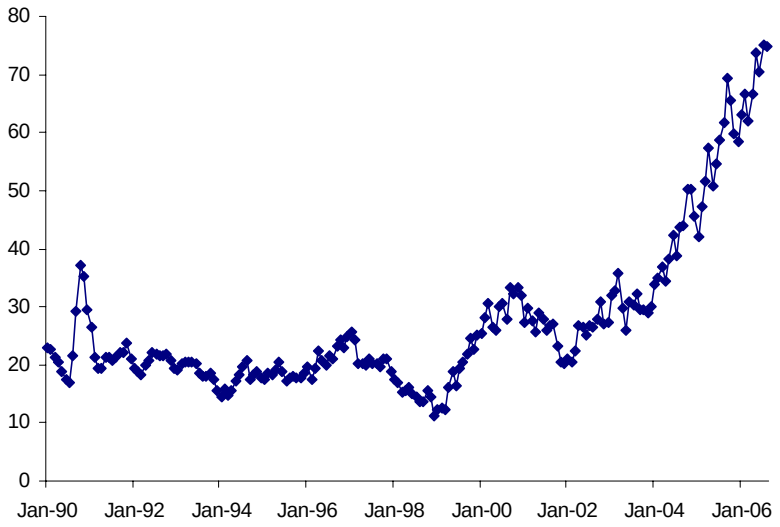

Figure 3: Petroleum Stocks (US, Japan, Europe), 1987-2006

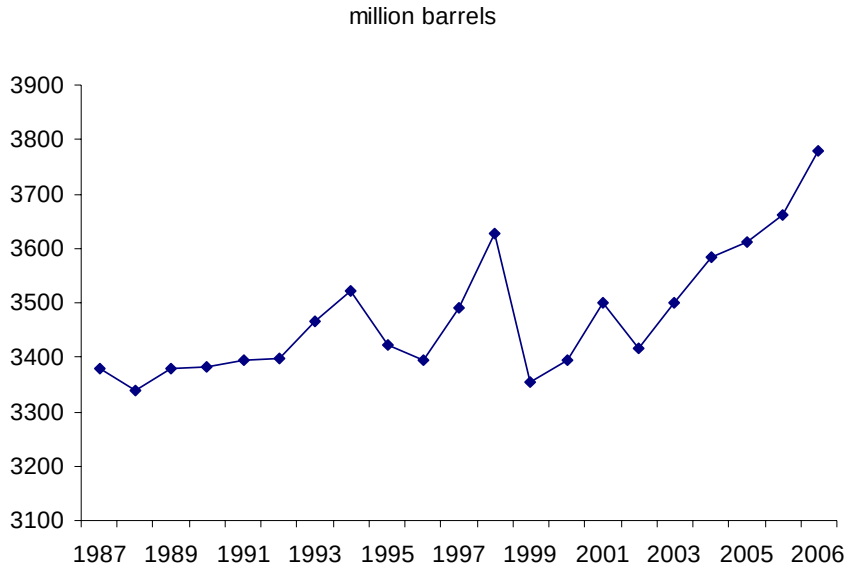

Table 1: Descriptive Statistics

	Spot	**Future2**	**Future3**
	Panel A: Full Period (1/1/1990 – 2/27/2006) N = 3913		
Mean	0.019%	0.058%	0.061%
Std. Dev.	2.513%	1.899%	1.766%
Maximum	18.297%	11.421%	9.347%
Minimum	-40.204%	-32.821%	-28.427%
Skewness	-1.285	-1.640	-1.376
Kurtosis	24.655	28.769	22.817
$\rho_{s,f}$		0.838	0.836
	Panel B: Pre 9/11 (1//1/1990 – 9/10/2001) N = 2842		
Mean	0.008%	0.034%	0.034%
Std. Dev.	2.561%	1.874%	1.734%
Maximum	18.297%	11.421%	9.347%
Minimum	-40.204%	-32.821%	-28.427%
Skewness	-1.480	-2.035	-1.760
Kurtosis	29.666	38.116	30.842
$\rho_{s,f}$		0.823	0.815
	Panel C: Post 9/11 (9/18/2001 – 2/27/2006) N = 1071		
Mean	0.050%	0.123%	0.130%
Std. Dev.	2.384%	1.964%	1.845%
Maximum	9.389%	5.863%	5.661%
Minimum	-16.531%	-15.720%	-12.161%
Skewness	-0.631	-0.738	-0.539
Kurtosis	6.470	7.947	5.881
$\rho_{s,f}$		0.883	0.898

Note: $\rho_{s,f}$ is the correlation coefficient for (spot,future2) and (spot,future3) pairs.

Table 2: OPEC and NON-OPEC Announcements.

	Full Period	Pre 9/11	Post 9/11
OPEC production hike	19	11	8
OPEC production cut	17	9	8
OPEC no change	26	12	14
Non-OPEC production hike	55	22	33
Non-OPEC production cut	36	6	30

Table 3: GARCH Models of Crude Oil Spot and Futures Daily Returns - Full Period Results (1/1/1990 – 2/27/2006).

Dependent Variable	(1) Spot	(2) Future2	(3) Future3
Const.	0.0002	-0.0011	-0.0010
	(0.9039)	(0.4297)	(0.4546)
σ	0.0238	-0.0771	-0.0568
	(0.7702)	(0.4246)	(0.5177)
TBILL	-2.7071	3.8593	2.9302
	(0.7905)	(0.6044)	(0.6711)
OPEC_UP	-0.0131***	-0.0105***	-0.0096***
	(0.0055)	(0.0079)	(0.0098)
OPEC_DN	0.0124***	0.0086**	0.0082**
	(0.0000)	(0.0322)	(0.0393)
OPEC_UC	0.0011	-0.0004	-0.0001
	(0.6944)	(0.8561)	(0.9429)
NOPEC_UP	-0.0097***	-0.0078***	-0.0067***
	(0.0010)	(0.0021)	(0.0040)
NOPEC_DN	0.0073***	0.0055***	0.0050***
	(0.0009)	(0.0014)	(0.0018)
TIME	-8.42E-08	7.15E-07	5.99E-07
	(0.9029)	(0.2237)	(0.2231)
SEP11	0.0008	0.0040**	0.0035**
	(0.7403)	(0.0343)	(0.0357)
Variance Equation			
Const.	-1.51E-05**	-2.72E-06	-2.12E-06
	(0.0223)	(0.1858)	(0.4164)
ARCH(1)	0.1373***	0.0694***	0.0685***
	(0.0000)	(0.0000)	(0.0000)
GARCH(1)	0.8222***	0.9196***	0.9176***
	(0.0000)	(0.0000)	(0.0000)
OPEC_UP	9.63E-06	3.23E-06	2.00E-06
	(0.8801)	(0.8972)	(0.9278)
OPEC_DN	-9.20E-05**	-4.60E-05*	-4.12E-05***
	(0.0394)	(0.0897)	(0.0000)
OPEC_UC	2.57E-05	1.64E-05	1.30E-05
	(0.4966)	(0.3843)	(0.4464)
NOPEC_UP	-4.20E-06	-3.42E-06	5.77E-07
	(0.9139)	(0.8609)	(0.9765)
NOPEC_DN	-8.91E-05***	-2.28E-05	-2.24E-05
	(0.0000)	(0.2180)	(0.1381)
TIME	1.29E-08	2.40E-09	2.13E-09
	(0.0428)	(0.3496)	(0.4232)
SEP11	5.00E-05***	9.44E-06*	9.06E-06*
	(0.0000)	(0.0579)	(0.0717)
Diagnostics tests			
Log-likelihood	9406.43	10380.08	10665.59
Q(5) serial correlation	0.011	-0.008	-0.005
	(0.761)	(0.565)	(0.841)
Q^2(5) ARCH effects	0.005	0.005	0.008
	(0.112)	(0.506)	(0.311)

Note: Coefficients marked with a * (**, ***) are statistically significant at the 1% (5%, 10%) level. P-values are in brackets.

Table 4: GARCH Models of Crude Oil Spot and Futures Daily Returns – Pre 9/11 Results (1/1/1990 – 9/10/2001).

Dependent Variable	(1) Spot	(2) Future2	(3) Future3
Const.	-0.0003	-0.0019	-0.0016
	(0.8444)	(0.1709)	(0.2198)
σ	0.0944	-0.0806	-0.0605
	(0.2086)	(0.4177)	(0.5106)
TBILL	0.7280	10.0927	7.6716
	(0.9487)	(0.2072)	(0.2931)
OPEC_UP	-0.0178***	-0.0130**	-0.0124***
	(0.0003)	(0.0113)	(0.0093)
OPEC_DN	0.0123***	0.0123**	0.0117**
	(0.0095)	(0.0166)	(0.0250)
OPEC_UC	-0.0045	-0.0005	0.0000
	(0.1919)	(0.8541)	(0.9948)
NOPEC_UP	-0.0132***	-0.0119**	-0.0098**
	(0.0027)	(0.0189)	(0.0239)
NOPEC_DN	0.0057**	0.0096*	0.0072
	(0.0323)	(0.0974)	(0.1706)
TIME	-4.41E-07	8.04E-07	6.77E-07
	(0.5174)	(0.1487)	(0.1555)
AR(2)		-0.0569***	-0.0558***
		(0.0063)	(0.0079)
Variance Equation			
Const.	-2.76E-05**	-1.92E-06	-1.51E-06
	(0.0393)	(0.6115)	(0.6493)
ARCH(1)	0.1214***	0.1015***	0.0972***
	(0.0003)	(0.0000)	(0.0000)
ARCH(2)	0.0901*		
	(0.0863)		
ARCH(3)	9.98E-02		
	(0.2226)		
GARCH(1)	0.4530	0.1970*	0.2127
	(0.1910)	(0.0736)	(0.1106)
GARCH(2)	1.01E-01	0.6870***	0.6730***
	(0.8364)	(0.0000)	(0.0000)
GARCH(3)	0.1160		
	(0.6509)		
OPEC_UP	6.23E-06	2.86E-05	2.16E-05
	(0.9478)	(0.5178)	(0.5561)
OPEC_DN	-1.21E-04***	-6.04E-05*	-5.03E-05*
	(0.0000)	(0.0529)	(0.0890)
OPEC_UC	5.88E-05	6.20E-05	5.25E-05
	(0.3623)	(0.1218)	(0.1393)
NOPEC_UP	9.94E-05	4.11E-05	3.72E-05
	(0.4158)	(0.4238)	(0.4498)
NOPEC_DN	-1.20E-04***	-4.95E-05	-4.19E-05
	(0.0000)	(0.2364)	(0.2425)
TIME	2.01E-08	2.24E-09	1.99E-09
	(0.1817)	(0.5627)	(0.5458)
Diagnostics tests			
Log-likelihood	6891.53	7658.88	7879.53
Q(5) serial correlation	0.007	0.013	0.016
	(0.488)	(0.398)	(0.738)
Q^2(5) ARCH effects	-0.006	0.002	0.004
	(0.466)	(0.238)	(0.106)

Table 5: GARCH Models of Crude Oil Spot and Futures Daily Returns – Post 9/11 Results (9/18/2001 – 2/27/2006).

Dependent Variable	(1) Spot	(2) Future2	(3) Future3
Const.	0.0002	0.0042	-0.0036
	(0.9896)	(0.7626)	(0.7693)
σ	-0.2406	-0.4462**	-0.3718*
	(0.2313)	(0.0454)	(0.0707)
TBILL	-38.1352	-54.1236**	-50.4174**
	(0.1902)	(0.0238)	(0.0307)
OPEC_UP	-0.0003	-0.0044	-0.0027
	(0.9497)	(0.4665)	(0.6306)
OPEC_DN	0.0040	0.0052	0.0052
	(0.6844)	(0.5216)	(0.4926)
OPEC_UC	0.0062	0.0018	0.0014
	(0.1676)	(0.5412)	(0.6092)
NOPEC_UP	-0.0075**	-0.0060**	-0.0051**
	(0.0109)	(0.0122)	(0.0219)
NOPEC_DN	0.0064***	0.0011	0.0012
	(0.0098)	(0.6095)	(0.5628)
TIME	0.00000165	1.74E-06	0.0000029
	(0.5322)	(0.4491)	(0.1880)
AR(1)	-0.0610		
	(0.0655)		
Variance Equation			
Const.	1.12E-04	2.97E-04***	1.39E-04***
	(0.3573)	(0.0000)	(0.0000)
ARCH(1)	0.0994***	0.0891***	0.0971***
	(0.0018)	(0.0020)	(0.0032)
GARCH(1)	-0.0535*	-0.0524	0.0262
	(0.0982)	(0.2160)	(0.7371)
GARCH(2)	0.7418***	0.6798***	0.6312***
	(0.0000)	(0.0000)	(0.0000)
OPEC_UP	7.39E-05	-1.71E-05	1.08E-05
	(0.8041)	(0.8683)	(0.9230)
OPEC_DN	2.93E-04	2.90E-04	2.45E-04
	(0.2025)	(0.2033)	(0.2255)
OPEC_UC	4.48E-05	-3.02E-06	-1.59E-05
	(0.6418)	(0.9601)	(0.7249)
NOPEC_UP	-1.39E-05	-6.11E-05*	-4.55E-05
	(0.8281)	(0.0794)	(0.1355)
NOPEC_DN	-2.12E-04***	-1.56E-04***	-1.34E-04***
	(0.0000)	(0.0000)	(0.0000)
TIME	1.08E-09	-3.82E-08***	-1.12E-08
	(0.9803)	(0.0062)	(0.3569)
Diagnostics tests			
Log-likelihood	2543.44	2766.77	2823.46
Q(5) serial correlation	-0.049	-0.071	-0.065
	(0.445)	(0.138)	(0.138)
Q^2(5) ARCH effects	0.029	0.026	0.018
	(0.528)	(0.456)	(0.669)

Table 6: Announcements and Trading Volume in Crude Oil Futures.

	Trading Volume		
	Full	Pre 9/11	Post 9/11
C	4.2199	4.0975	6.3087
	(0.000)	(0.000)	(0.000)
OPEC_UP	0.1481***	0.1751***	0.0899**
	(0.0006)	(0.0069)	(0.0342)
OPEC_DN	0.0471	0.0271	0.0756
	(0.2118)	(0.5751)	(0.2338)
OPEC_UC	0.0233	-0.0242	0.0736***
	(0.4978)	(0.7080)	(0.0078)
NOPEC_UP	0.0064	0.0336	-0.0175
	(0.8332)	(0.5454)	(0.5751)
NOPEC_DN	-0.0083	0.1184*	-0.0449*
	(0.7485)	(0.0684)	(0.0928)
TIME	8.99E-05***	8.25E-05***	2.38E-04***
	(0.0000)	(0.0000)	(0.0000)
SEP11	0.0725***		
	(0.0000)		
Adjusted R^2	0.6402	0.4289	0.4381

Note: Coefficients marked with a * (**, ***) are statistically significant at the 1% (5%, 10%) level. P-values are in brackets.