INTERNATIONAL MONETARY FUND

OPEC and the Oil Market

Yousef F. Nazer and Andrea Pescatori

WP/22/183

2022
SEP

 WP/22/183

IMF Working Paper
Research Department

OPEC and the Oil Market[1]

Prepared by Yousef F. Nazer and Andrea Pescatori

Authorized for distribution by Antonio Spilimbergo
September 2022

ABSTRACT: This paper studies the historical importance of OPEC for oil price fluctuations. An event-study approach is used to identify the effects of OPEC announcements on oil price fluctuations. Results show that price volatility is higher than *typical* around OPEC meetings. Also, members' compliance, a proxy for credibility, has strongly fluctuated over time. An ordered multinomial logit framework identifies the main factors that explain OPEC's decisions to cut, maintain, or boost members' oil production and is able to successfully predict OPEC meeting outcomes 66 percent of the time, between 1989 and 2019. Cyclical oil price fluctuations (as opposed to persistent shifts in levels) drive OPEC's decisions, suggesting that OPEC's objective is to stabilize the oil price rather than countering fundamental shifts in demand and supply. Low OPEC's market share reduces the probability of a production cut. Finally, the transparency of OPEC's statements has modestly improved between 2002 and 2019.

JEL Classification Numbers:	O13, Q41
Keywords:	OPEC Meetings, Credibility, Oil Price, Text Analysis, OPEC+
Author's E-Mail Address:	Ynazer@imf.org; Apescatori@imf.org

[1] We are grateful to Antonio Spilimbergo, Tim Callen, Martin Stuermer, Lukas Boer, Bahar Alberto, Abdullah Al-Hassan, Ömer E. Bayar, Moheb Malak, Issouf Samake for comments and Zhao Li for excellent econometric and programming assistance,

Table of Contents

Figures

Tables

Appendices and Supplementary Material

I. Introduction

What has been the role of the Organization of the Petroleum Exporting Countries (OPEC) in the oil market? Has its role evolved over time? This paper tests the ability that OPEC has had to influence the oil market by looking at the effects of OPEC's meetings on oil price levels and volatility between 1988 and 2019. It also studies the most relevant factors that can explain OPEC's production decisions, and it touches on recent developments such as the alliance between OPEC and other non-OPEC oil producers, OPEC+.

The stated objective of OPEC is to coordinate the petroleum policies of its Member Countries to *stabilize* the oil markets around a "fair" price.[2] The objective is, thus, in terms of both sustaining the oil price and reducing its volatility around an equilibrium level—a sufficiently vague statement that seems to incentivize the use of *discretionary* policy (as defined in Kydland and Prescott 1977) relative to adopting a *systematic* rule (i.e., a reaction function) that responds in a predictable manner to oil market developments.[3] OPEC, in fact, has a fragile organization structure (e.g., Adelman 1979, Fattouh and Mahadeva 2013) as it lacks a formal enforcement mechanism that can induce its members to comply with their quota allocations.[4] This paper, however, shows that OPEC's decisions have a *systematic* component because they are predictable, at least to some extent. Moreover, it is the surprise component of those decisions that affects the market since the same decision can induce a different price response.

Even though OPEC sometimes has difficulty enforcing its production quotas (Almoguera et al 2011), markets pay close attention to its announcements—this is not surprising since OPEC accounted for more than 40 percent of world oil production over the last three decades. The empirical evidence on the effects of OPEC on oil prices is, however, rather mixed: while some papers have found empirical evidence that its announcements can have a significant impact on oil prices (Lin and Tamvakis, 2010; Loutia, Mellios, and Andriosopoulos, 2016), others argue that this is only conditional on production cuts. For example, Demirer and Kutan (2010) and Guidi et al (2006) find an asymmetry in that only OPEC production *cut* announcements yield a statistically significant impact between 1983 and 2008.[5] Hyndman (2008) examines the effect of OPEC quota announcements during 1986–2002 on crude oil spot and two months futures prices. He finds positive and significant abnormal returns following meetings when OPEC reduces the aggregate quota. Also, Schmidbauer and Rösch (2009) found evidence that the oil market response to OPEC's announcements is more likely to depend on the decision. Brunetti et al (2013) look at OPEC's pronouncements about the *fair* oil price as perceived by the coalition, from 2000 to 2009, and finds no effects from OPEC's announcements that cite the fair price even when this one differs from current prices.

As we will show, the main problem with some event studies in the literature is that OPEC's decisions are not exogenous, but respond to the state of the oil market and global economy (Barsky and Kilian, 2004). This means that, even in the absence of information leaks, OPEC's decisions

[2] OPEC was established in 1960, but it became active only in the early 70s when most national oil companies (NOC) where funded. This gave the instrument to many oil exporting countries to affect oil investment and production decisions more directly. The OPEC's mission is "to coordinate and unify the petroleum policies of its Member Countries and ensure the stabilization of oil markets in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a *fair* return on capital for those investing in the petroleum industry" (OPEC).

[3] It is also worth noting that both oil production volumes and prices are not good instruments in the sense of Poole (1970).

[4] Systematic rules, transparency, and accountability have been the crucial ingredients for the success of many central banks in stabilizing private sector's inflation expectations in the 1990s (Bernanke and Mishkin 1997, Ball and Sheridan 2004, Woodford 2003, among others).

[5] "We also find that the persistence of returns following OPEC production cut announcements creates substantial excess returns to investors who take long positions on the day following the end of OPEC conferences." (Demirer and Kutan 2010).

are not random events but can be anticipated by markets to some extent; hence, their immediate impact on prices should reflect the element of the decision that *surprised* market participants.

Using an event study methodology around OPEC's concluding statements, we try to put some clarity to previous findings in the literature.[5] First, we divide decisions into three categories depending on their impact on the coalition oil output (cut, maintain, and increase in production) and show that OPEC's decisions do not *systematically* surprise market participants in any specific direction, regardless of the decision. (For example, production cuts are not systematically associated with price increases). Second, the volatility of oil market returns before and after the meetings is higher and fluctuate more than typically (i.e., the oil returns volatility around meetings dates is higher than in the control sample). Third, we look at a broader interval and differentiate between regular (calendar-based) and non-regular meetings (called in exceptional circumstances). Oil price movements around regular meetings seems to suggest that OPEC's decisions have a minor temporary impact on the oil price direction. The picture is different for non-regular meetings where the meeting's announcement has a strong impact on prices, often inducing a price correction.[6] Finally, the higher volatility found for the day after the announcement—2.2 and 3.1 percentage points higher than the median volatility for the regular and non-regular meetings, respectively —diminishes later on, suggesting that on average OPEC has tended to be a stabilizing force for the oil market, that is, market volatility drops below its median value in the control sample (and pre-meeting average) about 9-10 days after the conclusion of the meetings, especially for non-regular meetings.

Because of OPEC's varying conduct, the literature has argued that there is not a single model that fits well the OPEC's behavior (see, for example, Fattouh and Mahadeva 2013). Moreover, compliance of OPEC's members to the production agreements has fluctuated historically, mining OPEC's credibility in some periods. However, not only we have found that there is no systematic market reaction bias associated to OPEC's decisions, but we can also identify a few factors that are strongly related to the meetings' outcomes. Using a multinomial logit that is estimated to match cut, neutral, and boost decisions, we find that the cyclical component of oil prices is the most significant one—suggesting that cyclical movements in oil prices incorporate most of the relevant oil market information that is used in the OPEC's decision process. The trend component of the oil price is insignificant which suggests that OPEC does not react to fundamental changes in the oil market but tries to stabilize the oil price around a "fair" level. Another important factor that increases the probability of a cut is economic uncertainty while entering a meeting with a low Saudi oil market share reduces the probability of an (extra) cut.[7] Finally, a text analysis performed on concluding statements finds that OPEC's level of transparency has moderately fluctuated over time. A lesser number of repetitive statements were found around the Global Financial Crisis, during the 2008 oil price boom, and during the 2010 oil price recovery. Additionally, extraordinary meetings tend to have fewer repetitive statements than regular meetings, but the average difference is not significant.

In section VI, we provide our view about the recent developments in the oil market in the light of COVID-19 pandemic. In particular, we describe the potential complexity that might add to OPEC+ when market dynamics normalize.

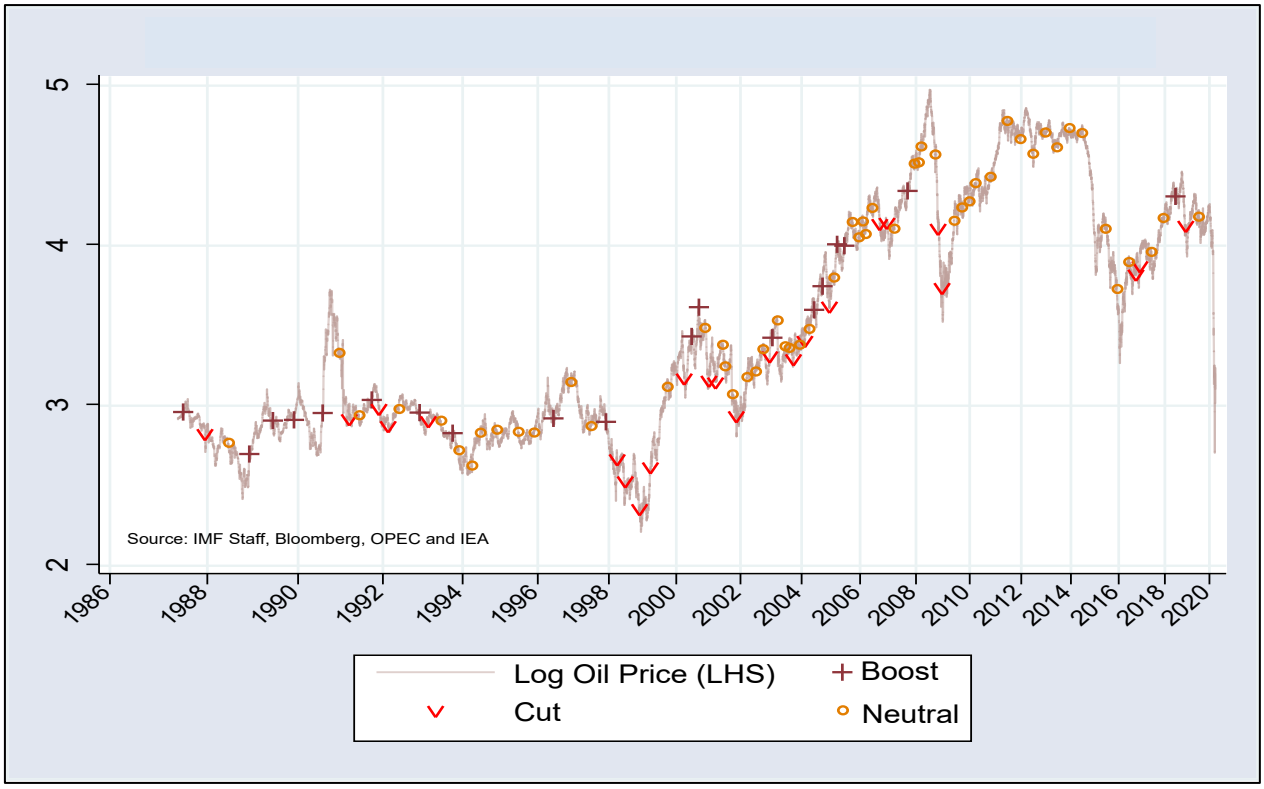
[5] The study of the determination of member country quotas is beyond the scope of the paper and not directly related to the question of whether and how OPEC affects the oil market.
[6] Non-regular meetings are usually announced 3-5 days before their start.
[7] The multinomial logit can predict the right outcome 2/3 of the times (see section iv).

The paper is structured as follows: Section II studies the market impact of OPEC announcements using an event study methodology; Section III analyzes OPEC member compliance; Section IV studies the drivers of OPEC decisions; Section V text analysis; Section VI discusses OPEC+ challenges; and section VII concludes.

II. The Impact of OPEC's Meetings on the Oil Market

This section studies the effect of the announcements of OPEC's decisions on (Brent) spot oil prices using an event-study methodology at daily frequencies. Widely used when high frequency data are available, event studies allow us—by focusing on a narrow time window—to attribute the price movements (or abnormal returns) to the realization of the event under consideration (MacKinlay 1997). Examples are various, including studying the effects on asset markets of Central Banks' policy rate decisions (Bernanke and Kuttner 2005), USDA crop announcements (Sumner and Mueller 1989), merger and acquisition, or corporate earnings announcements (Pevzner et al 2015).

Figure 1: OPEC announcement decisions



Note: Oil price is the log of the daily. Brent price

An approach that uses lower frequencies (e.g., monthly frequencies) may introduce a problem of reverse causality since OPEC tends to cut (boost) output when oil prices are low or falling (high or raising), see figure 1. For robustness, we have also used excess returns and 3-month Brent futures daily prices without finding qualitative differences.[8]

[8] The oil market's excess returns are calculated by regressing the daily oil price log-change on the SnP500 total returns and using its residual. Brent 3-month futures prices are only available since [1990]. Results are available upon request to the authors.

Our analysis covers 101 meetings from 1987 to 2019 [9]. OPEC meetings can be either regular (ordinary) or non-regular (extraordinary). The former has a fixed schedule while the latter is usually called upon in response to exceptional circumstances (e.g., after the 9/11 terrorist attack) and may be convened at the request of any OPEC country member. Out of 101 meetings 30 are non-regular meetings. Regular OPEC meetings usually last two days and conference resolutions become effective after 30 days.

To set the stage, we define the simple cumulative daily oil return $R_{k,j}$ and P_k is brent crude price that associated with the release of the concluding statement of the meeting k, the j-th day after the release, as

$$R_{k,j} = log\, P_{k+j} - log\, P_k;\ \ k \in D,\ j = 1, \dots, T \tag{1}$$

where T denotes the window over which returns are calculated and k belongs to the set of OPEC's meeting dates, D.

We similarly define the (opposite of the) cumulative returns prior to the meeting as

$$R^{-}_{k,j} = -\left(\log P_k - \log P_{k-j}\right);\ \ k \in D,\quad j = 1 \dots T \tag{2}$$

In this study, we assume a window of 11 trading days, T=11.

OPEC's main policy tool is to change the oil production target at the coalition (or sub-coalition level) and, especially before 2006, production quotas. [10] Qualitatively, three policy options are available: to cut, maintain, or boost oil production. In our sample there were 58 neutral decisions, 12 of them were taken in non-regular events.[11] Cut and boost decisions were 24 and 19, respectively.

Decisions require unanimity so consensus building is a fundamental part of the process which typically induces rumors and leaks that affect the oil market before the concluding resolution. The Kingdom of Saudi Arabia (KSA) is the recognized leading member since it holds the biggest production share (OPEC+ is analyzed in section VI).

How could we establish OPEC's *relevance* and *effectiveness*? Loosely speaking, relevance is the ability to affect the oil price in some ways. This is easy to establish: The oil price shows an abnormal volatility around OPEC meeting dates (including regular meetings, see figure 3). The abnormal volatility is observed even prior to the meeting, confirming that rumors and information leaks over the upcoming OPEC's resolution affect the oil market. Furthermore, anecdotally, episodes such as the counter-oil shock in 1986, the breakdown of OPEC in November 2014, or the

[9] From June 1987 to July 2019.
[10] For exceptional circumstances, such as wars, some members are exempted from complying with their quotas and are, thus, excluded from the calculation of the coalition production target.
[11] boost: 15 (R) and 4 (NR) total 19; Cut: 14 (R) and 10 (NR) total 24; Neutral: 42 (R) and 16 (NR) and total 58; Regular meeting 71 and non-regular 30.

price war of March-April 2020, have shown that OPEC's developments may strongly move the oil market. [12]

Effectiveness is the ability to steer the market in the desired direction (OPEC's goals): moving the oil price towards the *fair* price (and aiming at stabilizing it around that level). The fair price is, however, unobservable since OPEC stopped price targeting in 1983 by introducing the quota system. It is also not useful to look at the price reaction after a decision since markets try to anticipate the OPEC's decision reacting to the surprise component of that decision.

To formalize the argument let's assume that the oil price is driven by market fundamentals (such as oil demand and supply factors), x, and by the OPEC decisions, y (such as a production target for the group). The excess oil return t periods after the release of the concluding statement can be defined as $R_{k+t} = g(x_{k+t}, x_k) + \gamma_t y_k$ where $g_{k,t}$ is a function of a vector of market *fundamentals*, x, while γ_t captures the price reaction to the OPEC's decision (which may vary with OPEC's credibility and market share).

If k is the OPEC's meeting date, the returns' forecast errors can be written as

$$E\left[R_{k+t} \mid \Omega_{k-j}\right] - R_{k+t} = E\left[g_{k+t} \mid \Omega_{k-j}\right] - E\left[g_{k+t} \mid \Omega_{k+t}\right] + \gamma_t \left(E[y_k \mid \Omega_{k-j}] - y_k\right) \tag{3}$$

where Ω is the information set available to market participants the *j-th* day before the end of the meetings. Even if traders view on market fundamentals change in the chosen interval their average contribution should tend to zero in a narrow window of time, even if the *information* set Ω includes new information about market fundamentals. [13] Similarly, if markets can anticipate OPEC's decision to some extent, under rational expectations, there should be no systematic bias so that

$$\sum_{k=1}^{T} \left(E[y_k \mid \Omega_{k-j}] - y_k\right) / T \to 0 \tag{4}$$

So, if we split the decision into its expected and unexpected component

$$y_k = E[y_k \mid \Omega_{k-j}] + \left(y_k - E[y_k \mid \Omega_{k-j}]\right), \tag{5}$$

it is only the unexpected component that can move the market. Indeed, table 9 shows that there is no systematic bias since oil returns after the events are not systematically related to the OPEC's decision to cut, maintain, or boost output. This result is robust across time periods.

Even though results suggest that oil returns are unpredictable around OPEC's meeting, the mean squared forecast error will be greater than zero

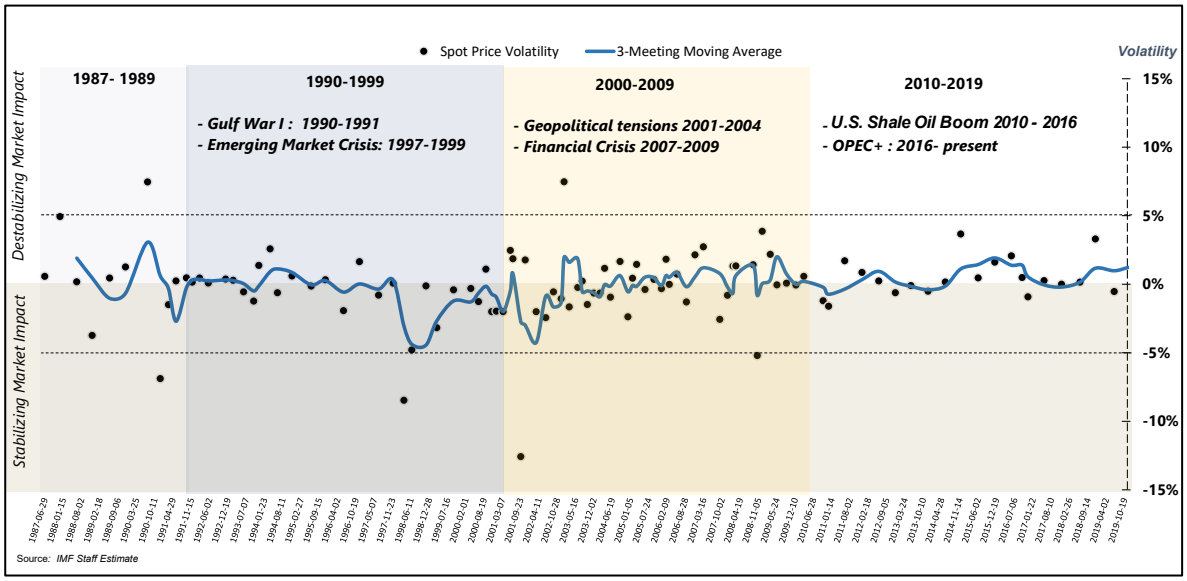
$$\sum_{k=1}^{T} \left(E[y_k \mid \Omega_{t-j}] - y_k\right)^2 / T > 0. \tag{6}$$

[12] Establishing the ability to affect the level of the oil price over the long run is beyond the scope of the paper. For analysis of the shift in oil market power see, for example, Nazer and Love (2020).

[13] Implicitly, we are assuming the OPEC has no time to react to changing market fundamentals in such a narrow window of time. It is, thus, recommendable to take *j=0*.

From equation (3), if $\gamma_t > 0$ then the volatility of the oil return increases above its typical level around the meeting dates unless decisions are perfectly predictable—which is not the case.

Figure 2: OPEC announcements: Effects on oil market



Note: The dots represent the difference between the standard deviation of oil price returns post and pre meeting, using asymmetric 11-days window, while the solid line is their 3-lags moving average.

Market stabilization

When taken at face value, not all OPEC's meetings have resulted in the stabilization of the oil price relatively to pre-meeting. Figure 2 plots the difference between the standard deviation of oil price returns post and pre meeting, using asymmetric 11-days window.[14] A casual inspection suggests that in some periods, especially in the second half of the 90s, OPEC played a stabilizing role, but not always. There are clearly episodes when the objective of OPEC was no longer stabilizing the market but regaining market share (see Section IV). These episodes, which are quite isolated, and leaks before the meetings generate a noise that blurs the actual effect of OPEC's decisions in Figure 2. We, thus, turn to a different approach.

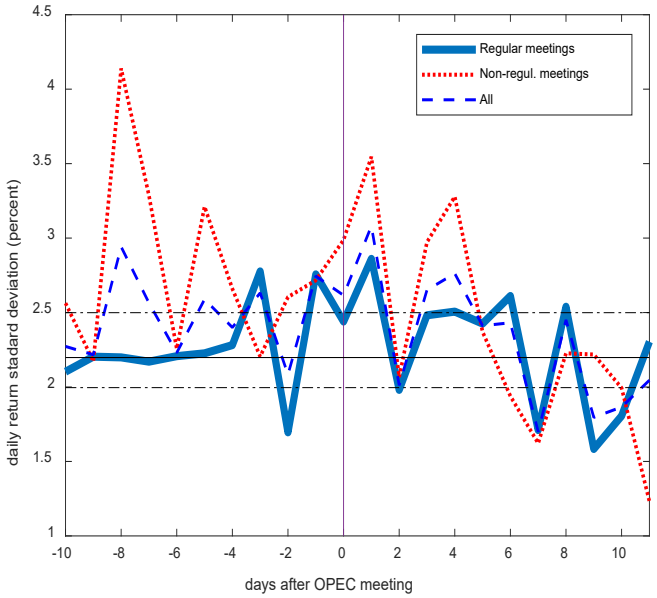
To understand how OPEC's decisions affect oil price volatility, it is useful to compare the distribution of oil price returns around the meeting dates with a *control distribution* which includes all trading days between 1989 and 2020—except the 3 days before and 6 trading days after the day of OPEC's concluding meeting. The daily Brent return's standard deviation of the control distribution is between 2.0 and 2.5 percent about 50 percent of the times with a median return of 2.2 percent.[15]

[14] Similarly, we have used 3 days window, but 11 days seems appropriate to identify market behavior before OPEC meetings. In addition, 3 days window is a smaller time horizon that reflects how the market behave for OPEC's announcement of the irregular meeting. We looked at the difference between the standard deviation of the log Brent price before and after the OPEC meetings: $std_{diff} = \left(\sqrt{\frac{\sum_{i=1}^{T}(P_{k+j}-\mu_{k-})2}{N}} - \sqrt{\frac{\sum_{i=1}^{T}(P_{k-j}-\mu_{k+})2}{N}}\right)$ where μ_{k+} (μ_{k-}) is the mean post (pre) meeting.

[15] The 10th and 90th percentile of the Brent oil return distribution is 1.8 and 3.1 percent, respectively. Excluding the very extreme events in 2020, the oil price return distribution is slightly skewed to the right since geopolitical events and unplanned oil supply disruptions lead to spikes in oil prices.

The volatility of the oil price daily returns increases as the conclusion of the regular meetings approaches. In particular, day three and day one before the release of the meeting's concluding statement show a higher oil return volatility than the typical volatility of the control distribution (about 0.6 percentage points higher than the median volatility, see figure 3. The day before the start of the meeting (day -2) shows an unusually low volatility (about 0.5 percentage point below the median volatility). The day after the concluding meeting, volatility peaks which implies that OPEC is relevant for the oil market being able to affect the oil prices. Not only, it means that decisions are not always fully anticipated. After the first market reaction to the news, however, the volatility declines afterward.

Figure 3: OPEC meetings price anomalies



Non-regular meetings are not on a fixed schedule and have usually been called in response to exceptional circumstances. Indeed, the volatility of oil return in the days before the non-regular meetings is almost twice as high as the typical median volatility of oil returns. After the meeting, the price volatility is abnormal about 3.5 percent—i.e., 1.3 percentage points above the median volatility. As days pass by, however, the reduction in the volatility is substantial falling from volatility. As days pass by, however, the reduction in the volatility is substantial falling from above the 75th percentile to below the 25th percentile of the control distribution.

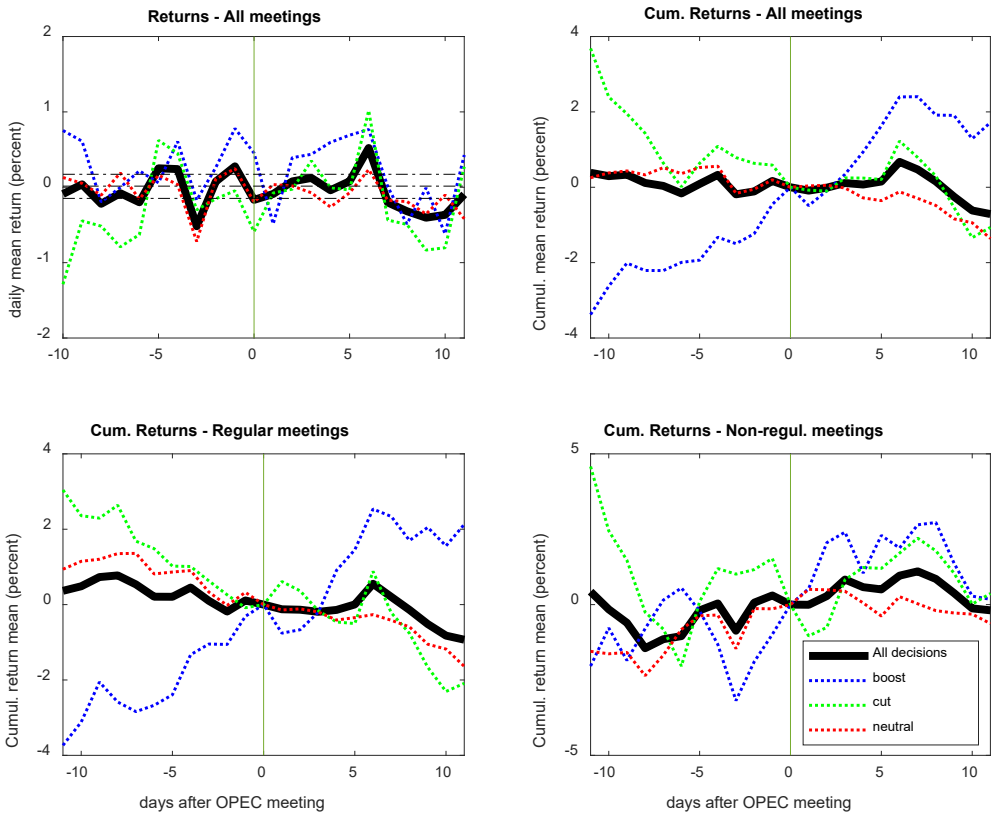
Overall results suggest that OPEC, in average, has affected the oil market. Even before the conclusion of the meetings, oil prices fluctuate more than typical—probably due to leaks and rumors that lead to speculative trading. The day after the concluding meeting also shows a higher volatility than typical, suggesting that the OPEC's decision move the market. Finally, as time goes by, the volatility is reduced, especially, for non-regular meetings, suggesting that OPEC, after affecting the price, has been a stabilizing force for the oil market. This is remarkably true for the non-regular meetings.

Effectiveness

It is not uncommon to find a production cut (boost) associated with a price decline (increase) as the size or timing of the decision may have disappointed (invigorated) the markets. In fact, despite the type of the decision, the averages daily return is typically quite noisy, including around meeting dates. It is, however, discernible that, in average, after a production cut the oil return increases while after a production boost it declines, relative to previous day (figure 4, top left). The cumulative returns (i.e., the evolution of the log oil price in deviation from its value at the meeting date) paint a clear picture. Let's first focus on regular meetings (figure 4, bottom left). Production boosts are typically preceded by an upward price trajectory that the production boost does not meaningfully alter—only towards the end of the time window the oil price appears to stabilize. Similarly, production cuts are preceded by falling prices that the production cut typically does not halt. In both cases, there is an initial effect (the day after the end of the meetings), but that effect

does not have a long-lasting impact on prices. Interestingly, an unchanged production is typically related to slightly falling prices prior to the meetings and has typically reduced oil returns after the meetings. Some neutral decisions probably were the result of a lack of agreement in providing price support (e.g., November 2014) or of an outright internal conflict (e.g., March 2020) that disappointed the market.

Figure 4: Oil returns around OPEC meetings

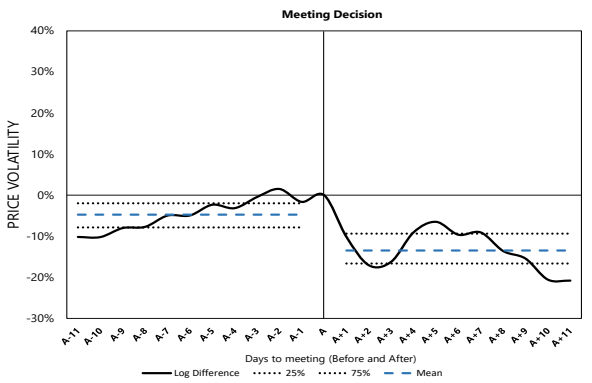


The picture is noisier for non-regular meetings. Since non-regular meetings are announced a few days before the meeting takes place, some of the price effect of that announcement happens before the conclusion of the meeting. In fact, for production boosts, it is visible that the price impact happens at least 6 days before the concluding meeting, similarly for production cuts. The price impact is substantial (about 3 percent), but it is not long-lasting, suggesting a market overreaction to the announcement of the meeting that fades as the meeting approaches.

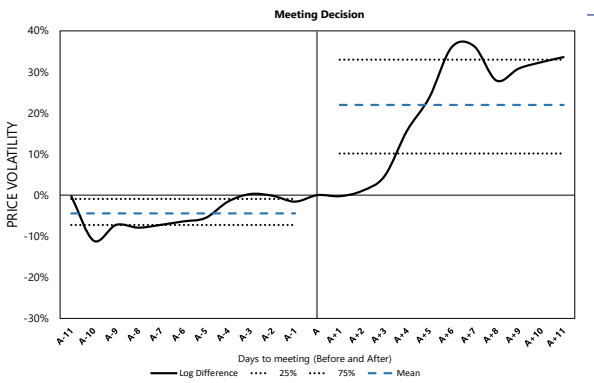
Some of the events analyzed where the price response was not statistically significant have been attributed to a well anticipated decision by markets. However, even though on average across the sample period OPEC has been shown to be relevant, it is possible that some decisions were perceived not credible. Ultimately, the lack of credibility must be related to a low degree of

compliance with the production quotas. In the next section we will analyze how OPEC compliance rates have evolved over time.

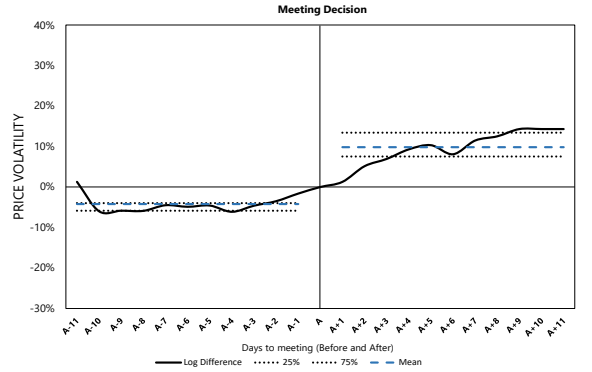
Figure 5: Selected OPEC meetings effects on oil market



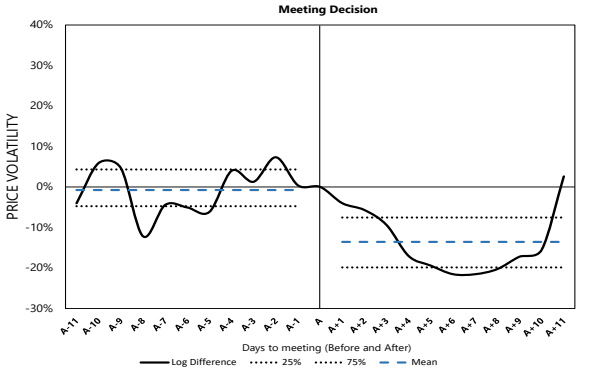
Date: Sep 11th, 2000 [Boost]
The New York Times: Faced with growing international pressure to drive down stubbornly high oil prices, OPEC agrees to increase oil production by 3 percent



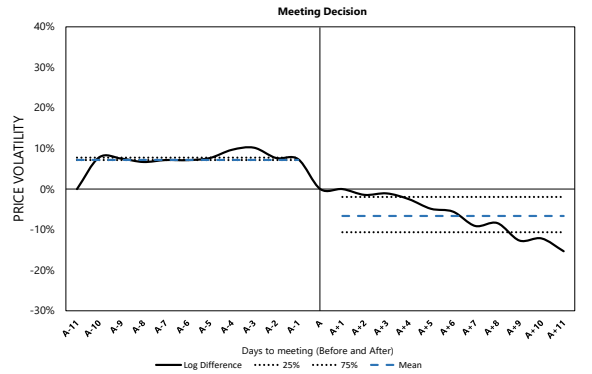
Date: July 27th, 1990 [Boost]
The New York Times: OPEC has tried to set price and production targets for its members, but the efforts have usually faltered because of a lack of discipline



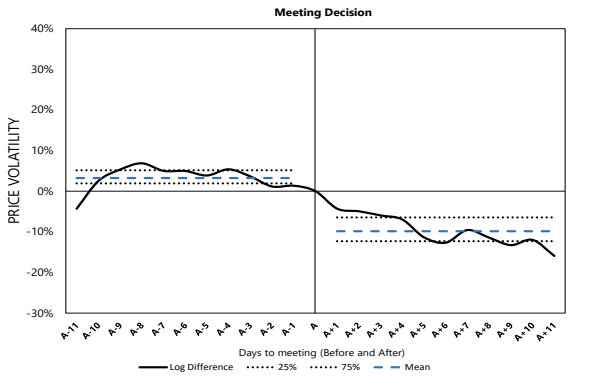
Date: Dec 12th, 2002 [Cut]
The Economist: OPEC's paradoxical move is aimed at curbing cheating. Combined with a strike in Venezuela and an impending war in Iraq, the news has pushed up oil prices



Date: Dec 17th, 2008 [Cut]
The Guardian: OPEC humbled as price of crude tumbles



Date: Dec 27th, 2014 [Neutral]
Reuters: Saudis block OPEC output cut, sending oil price plunging

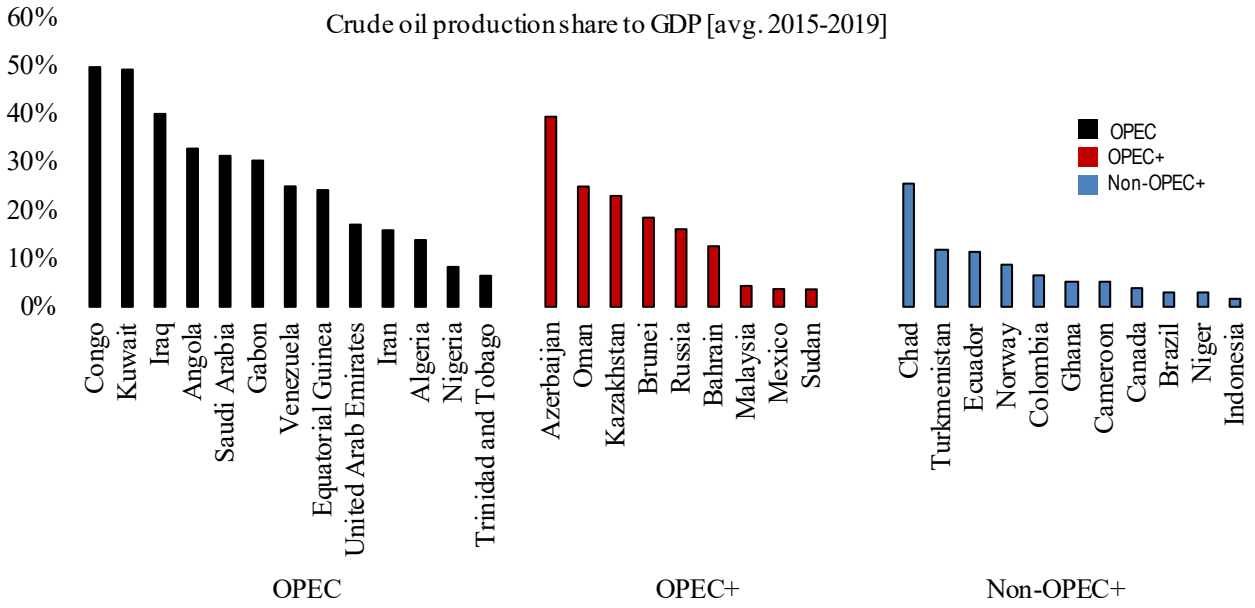


Date: Dec 14th, 2015 [Neutral]
Reuters: OPEC fails to agree production ceiling after Iran pledges output boost

III. Compliance and Credibility

OPEC decisions often involve a tradeoff between supporting (and stabilizing) the oil price and maintaining market share. Each member country, however, may assess such a tradeoff differently. Indeed, the extent to which OPEC's economies depend on oil differs from member to member, see figure 6. Moreover, the spare capacity, the fiscal position, the stage of the business and political cycle, the level of the inflation rate, the exchange rate system and amount of international reserves are additional factors that make the assessment of the above trade-off different across OPEC members. This makes the collective decision challenging and, thus, at times unpredictable.

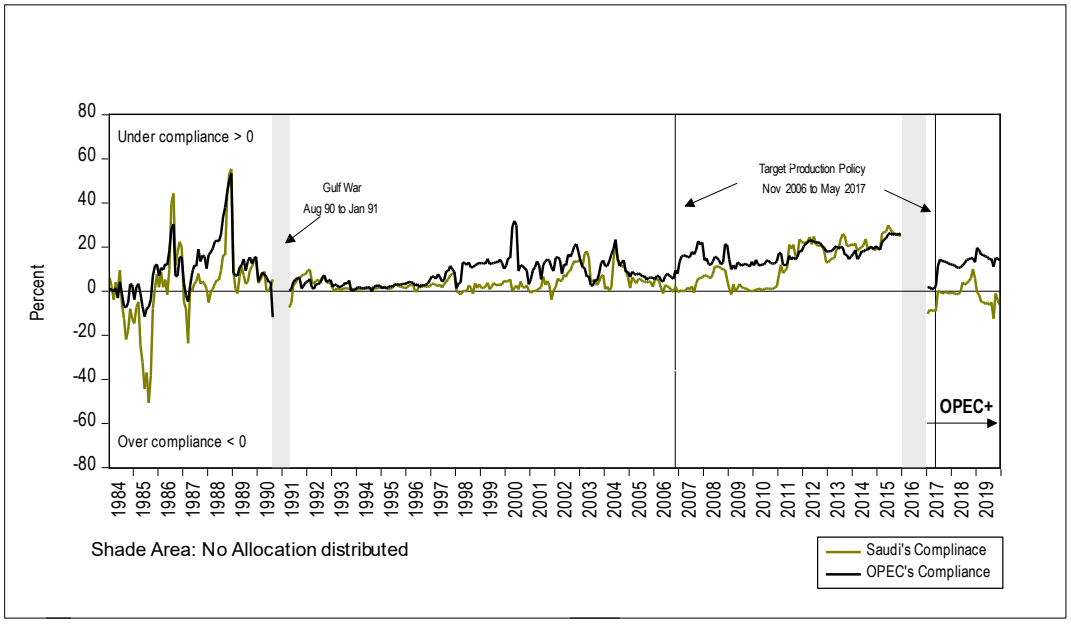
Figure 6: OPEC+ countries oil dependency



Sources: IEA, IMF, WEO and IMF staff calculations.
Note: OPEC membership assessed in April 2021 and excludes Libya.
There is a discrepancy between the chart and Iran's desk data regarding Iran's oil share in GDP. The results, however, remain unchanged.

Furthermore, especially for small producers, there is always the temptation of free riding given that there is no explicit enforcement mechanism in place to enforce the production allocation. Saudi Arabia, the de facto leader of the coalition, has usually played the role of swing producer—offsetting excess and under production (i.e., over- and under-compliance) of other OPEC members, especially before the 1990s and in the recent period. However, the benefits of this role are clearly asymmetric being the highest in case of production disruptions in other member countries but rather costly in case of demand shortfalls. On several events, Saudi Arabia was over compliant during the study period, demonstrating a higher level of discipline than any other OPEC member, see figure 7.

Figure 7: OPEC historical compliance



Source: OPEC, IEA, Fred, and IMF staff calculations.
Note: OPEC membership is based on 2019, allocation and production are based on historical composition.

The overall OPEC's compliance level, φ , can be defined as

$$(7) \qquad \varphi = 100\left[\frac{\sum_{i=1}^{n}\text{Production}_i}{\sum_{i=1}^{n}\text{Allocation}_i} - 1\right],$$

where n is the number of members in the coalition. If $\varphi > 0$ $(\varphi < 0)$ we have under (over) compliance at the coalition level. Clearly, country members can offset each other production excesses or deficiencies.

Figure 7 and table 1 show OPEC average compliance behavior for the last four decades. OPEC historical compliance level varies across time. To some extent, the compliance has been influenced by the different stage of the global economy. For example, in the 1980s, OPEC compliance was very deteriorated due to geopolitical tensions, but it reverted to stability between 1994 to 1999. Between 2011 and 2014, compliance declined given the strong growth in oil demand, but it eventually ended up exacerbating a supply glut US shale oil growth kept surprising on the upside.

The issue of compliance is challenging for OPEC, and it is hard to be solved under the current system where allocation rules are not fully defined (Fattouh, 2021). In general, it has probably led to a reduction in the OPEC's ability to affect the oil market efficiently. There is, however, no strong relation between periods of higher compliance and market volatility in our sample. Section VI, will discuss OPEC+ and the increased complexity of the new coalition.

Table 1: OPEC average production and compliance by decades

Average mbd	1984-1989				1990-1999			
	Average Allocation	*Average Production*	*Average Compliance*	*Aligne Production with Compliance*	*Average Allocation*	*Average Production*	*Average Compliance*	*Aligne Production with Compliance*
Algeria	*681*	*706*	*4%*	*708*	*770*	*774*	*0%*	*770*
Ecuador	*208*	*266*	*29%*	*269*	*273*	*352*	*12%*	*306*
I.R.Iran	*2402*	*2271*	*-6%*	*2265*	*3451*	*3516*	*2%*	*3534*
Iraq	*1583*	*1967*	*20%*	*1893*	*875*	*1064*	*7%*	*938*
Kuwait	*980*	*1352*	*38%*	*1349*	*1762*	*1713*	*5%*	*1848*
Libya	*1018*	*1059*	*4%*	*1059*	*1367*	*1416*	*3%*	*1414*
Nigeria	*1313*	*1450*	*10%*	*1445*	*1849*	*2063*	*12%*	*2071*
Saudi Arabia	*4481*	*4576*	*2%*	*4575*	*7807*	*8007*	*3%*	*8005*
U.A.E.	*979*	*1463*	*50%*	*1465*	*2106*	*2229*	*8%*	*2271*
Venezuela	*1596*	*1652*	*4%*	*1652*	*2367*	*2630*	*12%*	*2649*
Gabon	*152*	*172*	*14%*	*172*	*274*	*328*	*17%*	*320*
Total OPEC excl. Angola, Congo, Equatorial Guinea	*16598*	*18318*	*11%*	*18358*	*24047*	*25156*	*5%*	*25292*
**Total OPEC Production*		*18318*				*25156*		

	2000-2009				2010-2019			
	Average Allocation	*Average Production*	*Average Compliance*	*Aligne Production with Compliance*	*Average Allocation*	*Average Production*	*Average Compliance*	*Aligne Production with Compliance*
Algeria	*790*	*1166*	*48%*	*1167*	*828*	*1115*	*40%*	*1159*
Ecuador	*493*	*471*	*-1%*	*486*	*503*	*520*	*3%*	*517*
I.R.Iran	*3723*	*3790*	*2%*	*3803*	*3712*	*3198*	*-12%*	*3267*
Iraq	*NA*	*2087*	*NA*	*NA*	*NA*	*3657*	*NA*	*NA*
Kuwait	*2029*	*2267*	*12%*	*2265*	*2230*	*2697*	*22%*	*2721*
Libya	*1352*	*1538*	*14%*	*1538*	*NA*	*844*	*NA*	*NA*
Nigeria	*2087*	*2182*	*5%*	*2189*	*2006*	*1791*	*-5%*	*1906*
Saudi Arabia	*8239*	*8629*	*5%*	*8635*	*8816*	*9735*	*10%*	*9698*
U.A.E.	*2213*	*2348*	*6%*	*2345*	*2436*	*2810*	*16%*	*2821*
Venezuela	*2923*	*2661*	*-9%*	*2669*	*NA*	*2143*	*NA*	*NA*
Gabon	*NA*	*258*	*NA*	*NA*	*191*	*201*	*5%*	*202*
Total OPEC excl. Angola, Congo, Equatorial Guinea & Gabon	*25566*	*28625*	*12%*	*28660*	*26821*	*31403*	*16%*	*31166*
**Total OPEC Production*		*29194*				*31667*		

A. Allocation Data Source OPEC Annual Statistical Bulletin 1999, 2005 and 2020. Prorduction Data Source: IEA

B. Data reflect current members, "Ecuador suspended its membership in December 1992, but rejoined OPEC in October 2007, but decided to withdraw its membership of OPEC effective 1 January 2020. Indonesia suspended its membership in January 2009, reactivated it again in January 2016, but decided to suspend its membership once more at the 171st Meeting of the OPEC Conference on 30 November 2016. Gabon terminated its membership in January 1995. However, it rejoined the Organization in July 2016. Qatar terminated its membership on 1 January 2019", https://www.opec.org/opec_web/en/about_us/25.htm

C. No Allocation data for the period (Oct-1991 to Jan-1992) and (Oct-1992 to Dec-1992), (Nov-2007 to October-2008), and (Jan-2009 to Dec-2015), Simple Average has been taken instead.

D. Data in table represents averages per decade

*Total OPEC based on IEA historical composition.

**Compliance analysis: IMF staff calculation.

IV. Drivers of OPEC Decisions

This section explores some of the factors that tend to make one OPEC's decision more likely than another. In other words, we will look for variables that, known at the time of an OPEC meeting, can affect the probability of an agreement among OPEC's members on introducing production curbs, or keeping output as-is, or boosting it.

Nakov and Pescatori (2010) offers a stylized equilibrium model of the oil market with a dominant producer and a competitive fringe where the factors determining the production decision of the dominant oil producer can be derived. In that framework, the price of oil is a time-varying markup over marginal cost of oil production, where marginal costs are driven by technology trends in the extraction sector. The optimal markup is inversely related to the (absolute) price elasticity of demand for OPEC's oil and the dominant oil producer always chooses a point on the elastic segment of its effective demand curve. An increase in oil demand, will thus lead to both a higher oil price, markup, and production. An increase in non-OPEC output would, instead, erode the OPEC's market power reducing its markup (as well as oil prices).

Based on Nakov and Pescatori (2010), we can summarize the candidate factors that should explain, in part, OPEC's decisions. The first set of candidate factors are meant to capture current oil market demand conditions, the oil demand outlook, and forecast uncertainty around that outlook. A bleak outlook and elevated uncertainty should tend to increase the likelihood of a production cut. The second set of candidates is related to the OPEC's market power. A low OPEC share of global production should signal a reduced OPEC's market power and, thus, a lower probability of a production cut. Finally, anecdotally, OPEC production cuts are usually a response to declining oil prices. As some of the variables may not be available in real-time, oil prices (and, similarly, US or OECD oil stocks) may bring relevant information on the current and expected oil market tightness that is sufficient to influence OPEC's members toward a decision.

The chosen econometric model is an ordered multinomial logit. More specifically, we define the OPEC's meeting decision as $y = 0, 1, 2$; where 0 is a cut, 1 keeps production as is, and 2 is a boost in production. We assume that

$$(8) \qquad p_i = \Pr(y_i = i) = \Pr(k_{i-1} < x\beta + u \leq k_i)$$

$$= \frac{1}{1+\exp(-k_i+x\beta)} - \frac{1}{1+\exp(-k_{i-1}+x\beta)}$$

Where i=0, 1, 2, while x includes the 12-month ahead forecast of US GDP growth, the related forecast dispersion, and OECD stocks (set 1); Saudi Arabia share of oil production (set 2), the cyclical and trend component of the log of real Brent price (set 3) and other control variables such as the AAA-spread and the US T-bill rate (for robustness see Section). The trend and cyclical component are extracted using the Hodrick and Prescott date filter. The forecast dispersion, a measure of oil demand uncertainty, is orthogonalized relative to US GDP forecasts as the two variables are strongly negatively correlated (during recessions the forecast dispersion increases). In this way, we can distinguish the second from the first moment of the 12-month ahead GDP growth distribution. Oil inventories are a proxy for market tightness; however, they cannot tell whether it is demand or supply that drives the tightness.[16] All variables are known at the time of

[16] Oil stocks data are available only for OECD countries during the sample period.

the meeting. The sample includes all OPEC meetings from November 1989 to December 2018 for a total of 95 meetings.

A. Baseline Results

The fit of the baseline model is relatively good. The McFadden pseudo R^2 is 0.16. To provide a more practical sense of the goodness of fit, it is possible to define a signal, s_t, for a decision-j (j=0, 1, 2) by looking at the highest fitted probability—i.e., $s_t = j$, with $j = i^*$ such as $\mathrm{p}_{i^*} = \max_{i=\{1,2,3\}}\{p_{ti}\}$.

The model sends a correct signal a remarkable 66 percent of the times (see table 2 and figure 8).[17] It does, however, over predict the neutral outcome.[18]

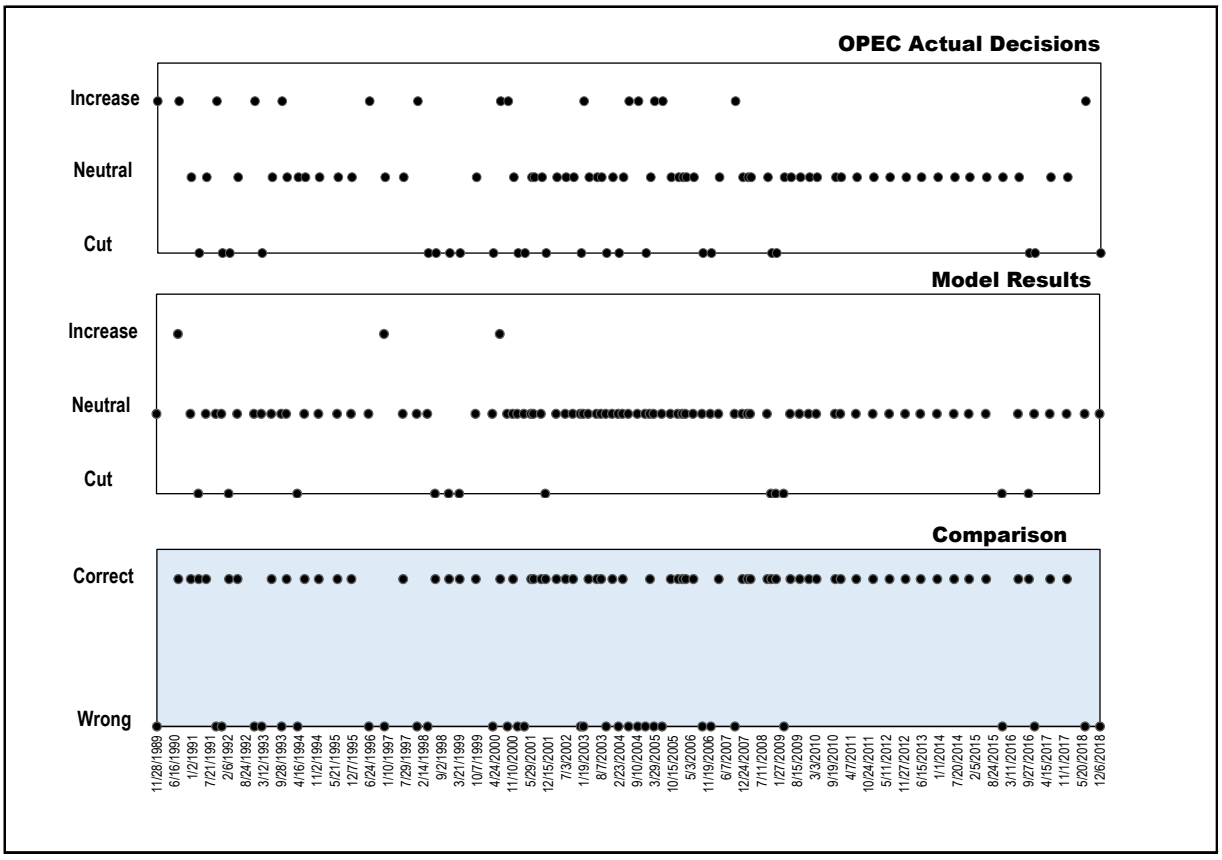
Table 2: OPEC decision prediction results

	Actual		Prediction		
Decision	Freq.	Percent	Freq.	Percent	Correct
cut	23	24.2	12	12.6	39%
neutral	56	59.0	80	84.2	93%
boost	16	16.8	3	3.2	13%
Total	95	100			66.3%

Note: Sample period for OPEC decision prediction 1989-2019.

Results in table 2 strongly support a fundamental role for oil prices as crucial indicators of oil market conditions and the main variable to which the OPEC reacts. Oil prices, however, are only mildly significant

Figure 8: Multinomial logit framework results



[17] Relative to a model with just the intercepts (i.e., the cutting points "k") the covariates introduced the McFadden $R^2 = 1 - \ln(L)/\ln(L_0)$, where L is the likelihood and L_0 is under the null of no covariates.

[18] A signal for an outcome j is given when the probability of that outcome is the highest. We could maximize the in-sample signal-to-noise ratios by finding threshold for each signal j that minimize the signal-to-noise ratio as in the early warning indicators literature (Demirgüç-Kunt, and Detragiache 1998). This is, however, beyond the scope of the paper.

when introduced in (log) levels, in part because they are not stationary over the sample period.[19] Once oil prices are decomposed in a trend and cycle component it is evident that only the cyclical component brings information for the OPEC decision. This result is very robust and suggests that OPEC aims at *stabilizing* prices around a medium-term *equilibrium price* which is, instead, dictated by supply and demand fundamentals that are beyond the control of OPEC. Deviations from this typical behavior might also be driven by non-economic factors, such as geopolitical considerations or an OPEC internal power struggle, which, at times, enter the equation in an unpredictable manner.[20]

It is likely that oil demand conditions are mostly captured by the cyclical movements of oil prices since the US GDP growth forecasts have the right sign but are not significant once the cyclical oil price is introduced. What oil prices cannot fully capture, however, is oil demand uncertainty. The forecast dispersion for US GDP growth is a proxy for forecasting uncertainty (Rich et al 1992) and, in this context, for oil demand uncertainty. Forecast dispersion enters with a negative sign and it is statistically significant at 3 percent. High oil stocks increase the probability of a production cut, but once the cyclical oil price is introduced, they are no longer significant, suggesting that inventories per se do not bring additional information for the OPEC's decision in addition to oil price movements.

Table 3: Baseline specification model results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log Real Brent Oil Price	0.697*						
	-2.01						
Oil Brent Hodrick and Prescott filter cyclical		5.417***	5.236***	5.466***	6.228***	6.891***	6.177***
		-4.52	-4.44	-4.62	-4.86	-4.93	-4.01
Oil Brent Hodrick and Prescott filter trend		-0.0593	0.0154	-0.0877	0.246	0.593	0.228
		(-0.14)	-0.04	(-0.21)	-0.51	-1.13	-0.36
GDP forecast			0.132	0.114	0.102	0.0275	0.105
			-0.56	-0.5	-0.48	-0.11	-0.49
GDP forecast standard deviation				-2.569	-4.618*	-4.396	-4.668*
				(-1.34)	(-2.19)	(-1.95)	(-2.17)
Saudi Production Share					-64.36*	-76.75**	-63.87*
					(-2.38)	(-2.79)	(-2.18)
Aaa Corporate Bond Yield						-0.605	
						(-1.10)	
3-Month Treasury Bill Rate						-0.705	
						(-1.28)	
OECD Stock							-3.8E-07
							(-0.06)
cut1	-2.275***	-1.218	-1.009	-0.897	-10.57*	-15.10**	-10.46*
	(-4.24)	(-1.87)	(-1.30)	(-1.19)	(-2.50)	(-2.79)	(-2.18)
cut2	0.536	1.994**	2.203**	2.354**	-7.091	-11.56*	-6.989
	-1.11	-2.99	-2.72	-3.01	(-1.78)	(-2.20)	(-1.53)
N	95	95	95	95	95	95	95

t statistics in parentheses
p*<0.05 ** p<0.01 *** p<0.001

[19] A unit root cannot be rejected for the log of real Brent prices and a positive trend as prices increased by 6 percent over the sample period.
[20] The 2020 March price war can be seen as an internal power struggle.

Table 4: Performance and descriptive statistics

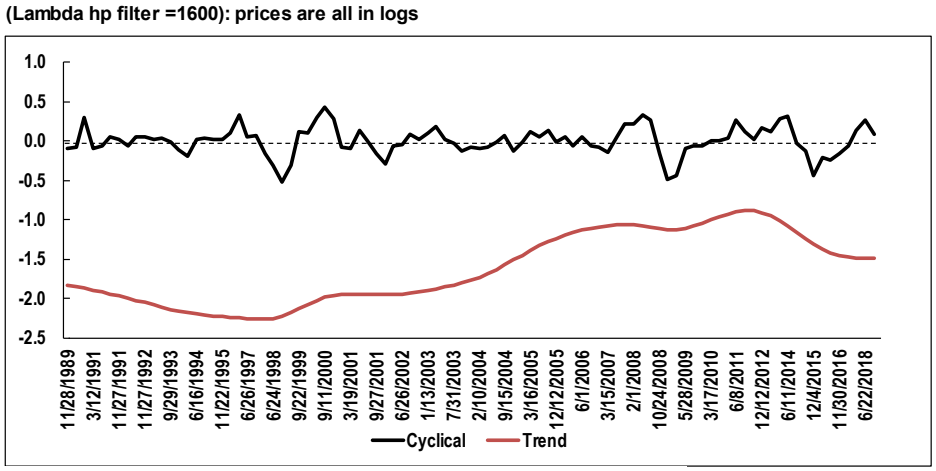
Variable	Obs	Mean	Std.	Min	Max
Oil Brent Hodrick and Prescott filter Cyclical	95	0.0	0.18	-0.52	0.43
Oil Brent Hodrick and Prescott filter Trend	95	-1.6	0.45	-2.26	-0.89
GDP Forecast	95	2.5	1.11	-1.99	4.53
GDP Forecast standard deviation	95	0.0	0.10	-0.20	0.26
Saudi Production Share	95	0.1	0.01	0.09	0.16

Note: Obs is the number of OPEC meetings (95) from November-1989 to December-2018.

The production shares of Gulf Corporations Countries (GCC) countries are usually significant and with a negative price (i.e., a low share reduces the probability of a cut). The Saudi Arabia's share of oil production, lagged by one month, is the most significant, improving the goodness of fit of the model. A one standard deviation (i.e., about 1 percentage point) decline in Saudi share of global oil production entering the meetings decreases the probability of a cut by 0.10 and increases the probability of a production increase by 0.08 see table 3.

Cyclical movements in oil prices have the highest economic impact. A one standard deviation (i.e., a 17 percent) increase in the cyclical component of oil prices induces a 0.16 reduction in the probability of a cut and increase the probability of a boost by 13 percent. Uncertainty has also a relevant economic impact, a one standard deviation increase in economic forecast uncertainty induces a 0.07 increase in the probability of a cut.

Figure 9: Hodrick–Prescott real oil price decomposition



Source: Federal Reserve Bank of St. Louis, and IMF staff calculations.

B. Robustness

We have conducted a battery of robustness checks to include additional explanatory variables and a shorter sample period. The main conclusions are unaltered. When oil prices are not introduced and decomposed into a cycle and trend, the time trend becomes significant. Interestingly, futures prices have less explanatory power than spot prices.[21] Also the contango enters with the expected sign (a contango market should favor a cut as it signals a well-supplied market), however, it is not significant. The role of the Saudi market share is also robust to a shorter sample period (starting in

[21] Data availability has constrained the analysis to use 3-month futures since longer dated futures contracts were introduced later in the mid- to late-90s.

the 2000s). Economic uncertainty, however, is no longer significant, as the number of economic cycles is reduced to one. Even though OECD oil stocks is significant, the sign is not the expected one.

Table 5: Different specification model results

OPEC's Decisions, Different Specifications	(1)	(2)	(3)	(4)	(5)	(6)
Log Real Brent Spot Price	0.697*	2.229***	2.894***		1.990**	
	-2.01	-3.73	-3.84		-2.92	
Time		-0.0365**	-0.0417**	-0.0311*	-0.0331*	
		(-2.64)	(-2.65)	(-2.19)	(-2.21)	
Trade Weighted U.S. Dollar Index			0.0273			
			-1.01			
Log Real Brent Spot Price			-0.158			
			(-0.42)			
Brent Future				1.862**		
				-2.81		
Contango					-1.625	
					(-1.05)	
Oil Brent Hodrick and Prescott filter Cyclical						9.140***
						-4.28
Oil Brent Hodrick and Prescott filter Trend						2.689**
						-2.62
GDP Forecast						0.253
						-0.75
GDP Forecast standard deviation						-3.009
						(-1.14)
Saudi Production Share						-101.0*
						(-2.17)
OECD Stock						0.0000183*
						-2.32
cut1	-2.275***	-6.633***	-5.92	-5.727**	-6.099***	-18.92*
	(-4.24)	(-4.02)	(-1.85)	(-3.25)	(-3.32)	(-2.50)
cut2	0.536	-3.598*	-2.853	-2.801	-3.043	-14.75*
	-1.11	(-2.34)	(-0.91)	(-1.69)	(-1.74)	(-2.00)
N	95	95	95	95	95	67

t statistics in parentheses
* p<0.05 ** p<0.01 *** p<0.001

V. OPEC's Communication

This section uses a text analysis to analyze OPEC's communication. We study the text of 58 OPEC meeting concluding statements from 2002 to 2019 –from the 119th to the 177th meeting – two "Consultative Meeting of the OPEC Conference", and 51 "opening address statements". The goal of the text analysis is to show the informativeness of statements and how it may have changed over time.

To test whether OPEC statements are repetitive and, thus, not informative, we use the cosine similarity metric method, and term-frequency-inverse document frequency (TF-IDF) techniques.[22] These two approaches will help us identify whether OPECs' statements are constructed in similar

[22] The assumption is that, at the extreme, a perfectly repetitive statement brings little or no information on how OPEC react to the oil market developments which have been at times dramatic in the period under consideration. Providing richer information to the public should, in turn, be associated with a higher transparency of the decision-making process.

fashion or not. We found that the level of transparency – adding more information – in OPEC statements has been modestly fluctuating over time. Less repetitive statements, in fact, were found around the global financial crisis, during the 2008 oil price boom and the 2010 fast oil price recovery and subsequent years. Statements related to extraordinary meetings are also less repetitive, but the average difference with regular meeting is not substantial, see table 6. Since the establishment of OPEC+, OPEC concluding statements (which are released one day before the OPEC+ statement) have become less informative, consistently with a growing relevance of OPEC+'s decisions over OPEC and the importance of Russia in the new coalition of oil exporters.

The statement very rarely refers to geopolitical or weather events while it constantly highlights supply conditions even more than demand conditions (figure 10). [23] This may simply reflect the fact that, being a coalition of producers, OPEC gives more emphasis to the variable over which they can exert some control, i.e. oil supply.

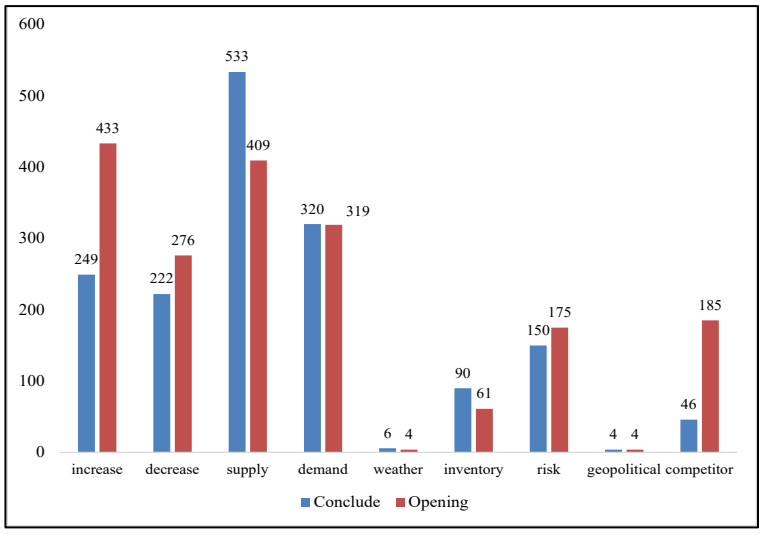
Table 6: Similarity analysis for OPEC concluding statements

Regular	Raw	TF-IDF	Stem
Cut	0.75	0.44	0.53
Boost	0.75	0.45	0.53
Neutral	0.72	0.41	0.48
All	0.73	0.42	0.50

Extraordinary	Raw	TF-IDF	Stem
Cut	0.71	0.40	0.48
Boost	0.75	0.46	0.54
Neutral	0.70	0.41	0.48
All	0.71	0.41	0.49

All (Regular and Extraordinary Statements)	0.72	0.42	0.49

Figure 10: OPEC statements word count dictionary

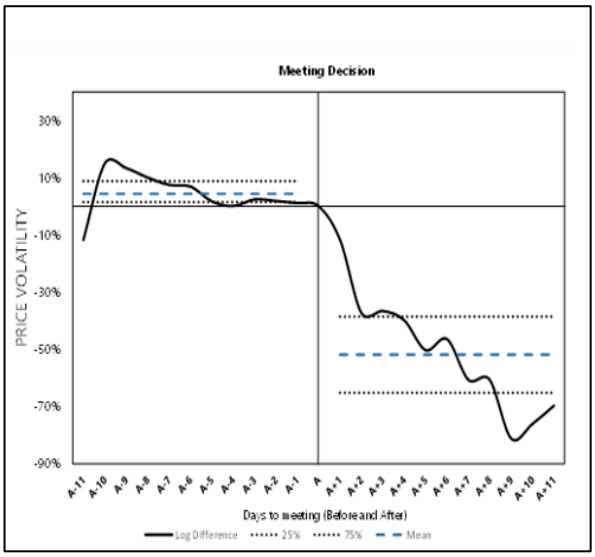


[23] To analyze the text, we 1) tokenize the documents – convert each document into individual words; 2) create a dictionary of word frequency: supply, demand, increase, decrease, weather, inventory, risk, geopolitical, competitor.

VI. OPEC+

An analysis of the most recent events would require considering the enlarged OPEC+ coalition which includes a group of non-OPEC oil exporter countries (including Russia).[24] In fact, the informal alliance between OPEC and Non-OPEC producers, widely known as OPEC+, represents about 60 percent of the global crude oil production, clearly enhancing the ability of the joint coalition to affect the oil market.

Figure 11: OPEC+ price war 2020



The new coalition, however, is more unstable than OPEC since its governance and double leadership (KSA and Russia) add complexity to the decision-making process. A recent case in point is the March 2020 "price war" when Russia and KSA clashed on how to respond to the looming collapse in oil demand driven by the pandemic. After negotiations broke down, surprising the markets, the oil prices quickly collapsed by more than 50 percent, far more than equity markets, see figure 11.

In relation to governance, one of the problems is that the OPEC's meeting concludes (and a statement is released) before the start of the OPEC+ meeting. This means that the indications given to markets by the OPEC concluding statement might be contradicted in a few days. In fact, the OPEC's concluding statement, gives recommendations for the subsequent OPEC+ consultations.

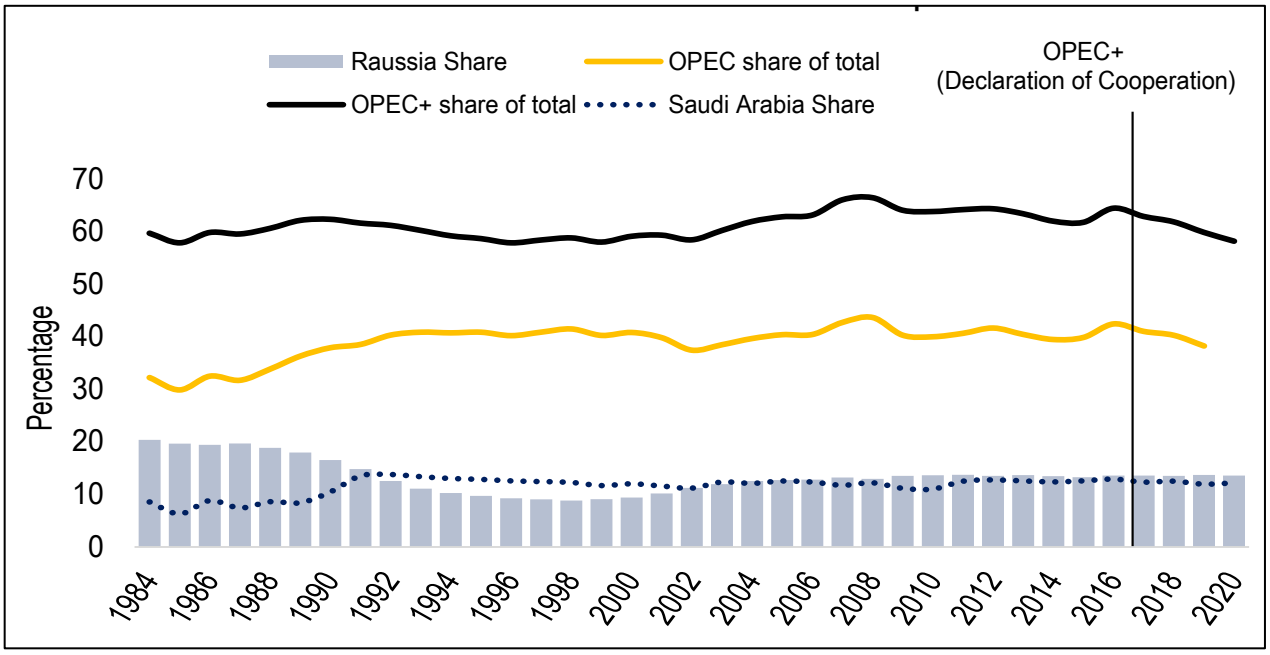
In March 2020, the *recommendations* were not followed by the non-OPEC members leading to a collapse of the OPEC+ coalition, followed by the subsequent price war as in a tit-for-tat strategy game.[25] So, an event study analysis must take into account that the OPEC concluding statement has now lost some of its relevance in part substituted by the one of OPEC+.

Do OPEC+ decisions have different effects on the oil market than OPEC in the older regime? In general, two forces will operate in opposite directions: 1) a higher market share will give more weight to OPEC+ decisions 2) the instability of the coalition may reduce the medium-term credibility of the decisions. During the pandemic, given the high levels of compliance, OPEC+ was able to stabilize the oil market implementing unprecedented production cuts led by Saudi Arabia and Russia. However, a full-fledged analysis of the impact of OPEC+ on the oil market should wait until more data are available.

[24] After an extended period of price decline, in the Fall 2016, Saudi Arabia and Russia engaged in negotiations aiming at a greater cooperation to stabilize the oil market—which had been hit by US shale oil boom. Ten days after the 171st OPEC meeting concluded, the first OPEC and non-OPEC joint statement was released on December 10, 2016.

[25] "[…] the Conference decided to *recommend* […] to the 8th OPEC and non-OPEC Ministerial Meeting a further adjustment of 1.5 mb/d until 30 June 2020 to be applied pro-rata between OPEC (1.0 mb/d) and non-OPEC producing countries (0.5 mb/d) participating in the Declaration of Cooperation." (OPEC 178th Meeting, concluding statement, March 2020).

Figure 12: OPEC vs. OPEC+ market share



Source: IEA, IMF staff calculations

VII. Conclusions

We employ an event study methodology to find that OPEC's decisions are not systematically missed by market participants. However, surprise decisions do induce sharp oil price movements regardless of the decision taken as it is the surprise component of the decision that can induce sizeable price corrections. Also, in average, the volatility of oil market returns before and after the meetings are higher than typical (i.e., higher than volatility found using a random sample of dates).

The above results are consistent with OPEC (and OPEC+) following a systematic decision rule in reaction to market developments. The logit analysis shows that among the factors behind OPEC's decisions to cut, keep, or increase production targets, the cyclical component of oil prices is the most significant one, as it incorporates most of the relevant oil market information. The trend component is insignificant which suggests that OPEC does not react at fundamental changes in the oil market but tries to stabilize the oil price around a "fair" level. Another important factor that increases the probability of a cut is economic uncertainty while a low Saudi oil market share significantly reduces the probability of an (extra) cut.

References

Adelman, M. A. (1980). Clumsy cartel. [Overcapacity/supply problems]. *Energy J.;(United States)*, *1*(1).

Almoguera, P. A., Douglas, C. C., & Herrera, A. M. (2011). Testing for the cartel in OPEC: non-cooperative collusion or just non-cooperative? Oxford Review of Economic Policy, 27(1), 144-168.

Ball, L., & Sheridan, N. (2007). 6. Does Inflation Targeting Matter? (pp. 249-282). University of Chicago Press.

Barsky, R. B., & Kilian, L. (2004). Oil and the macroeconomy since the 1970s. *Journal of Economic Perspectives*, *18*(4), 115-134.

Bernanke, B. S., & Mishkin, F. S. (1997). Inflation targeting: a new framework for monetary policy?. *Journal of Economic perspectives*, *11*(2), 97-116.

Bernanke, B. S., & Kuttner, K. N. (2005). What explains the stock market's reaction to Federal Reserve policy?. *The Journal of finance*, *60*(3), 1221-1257.

Burke, P. J., & Csereklyei, Z. (2016). Understanding the energy-GDP elasticity: A sectoral approach. *Energy Economics*, *58*, 199-210.

Brunetti, C., Büyükşahin, B., Robe, M. A., & Soneson, K. R. (2013). OPEC" fair price" pronouncements and the market price of crude oil. *The Energy Journal*, 79-108.

Collier, P., & Venables, A. J. (2012). Greening Africa? Technologies, endowments and the latecomer effect. Energy Economics, 34, S75-S84.

Csereklyei, Z., Rubio-Varas, M. D. M., & Stern, D. I. (2016). Energy and economic growth: the stylized facts. *The Energy Journal*, *37*(2).

Dargay, J., Gately, D. (1999). "Income's effect on car and vehicle ownership, worldwide: 1960–2015. *Transportation Research Part A: Policy and Practice*, *33*(2), 101–38.

Dargay, J., Gately, D., & Sommer, M. (2007). Vehicle ownership and income growth, worldwide: 1960-2030. *The energy journal*, *28*(4).

Demirgüç-Kunt, A., & Detragiache, E. (1998). The determinants of banking crises in developing and developed countries. *Staff Papers*, *45*(1), 81-109.

Draper D. W. (1984). The behavior of event-related returns on oil futures contracts. *The Journal of Futures Markets (pre-1986)*, *4*(2), 125.

Energy Information Administration - Eia - Independent Statistics and Analysis." Petroleum, Natural Gas, and Coal Still Dominate U.S. Retrieved May 13, 2021

Fattouh, B., & Mahadeva, L. (2013). OPEC: what difference has it made?. *Annu. Rev. Resour. Econ.*, *5*(1), 427-443.

Fattouh, B. (2021). *Saudi Oil Policy: Continuity and Change in the Era of the Energy Transition*. Oxford Institute for Energy Studies.

Fraiberger, S. P., Lee, D., Puy, D., & Ranciere, R. (2018). *Media sentiment and international asset prices* (No. w25353). National Bureau of Economic Research.

Hyndman, K. (2008). Disagreement in bargaining: An empirical analysis of OPEC. International Journal of Industrial Organization, 26(3), 811-828.

Guidi, M. G., Russell, A., & Tarbert, H. (2006). The effect of OPEC policy decisions on oil and stock prices. *OPEC review*, *30*(1), 1-18.

Kydland, F. E., & Prescott, E. C. (1977). Rules rather than discretion: The inconsistency of optimal plans. *Journal of political economy*, *85*(3), 473-491.

Lin, S. X., & Tamvakis, M. (2010). OPEC announcements and their effects on crude oil prices. Energy Policy, 38(2), 1010-1016.

MacKinlay, A. C. (1997). Event studies in economics and finance. *Journal of economic literature*, *35*(1), 13-39.

OPEC. (2010). OPEC Monthly Oil Market Report.

OPEC. (2020). OPEC Annual Statistical Bulletin.

Nakov, A., & Pescatori, A. (2010). Monetary policy trade-offs with a dominant oil producer. *Journal of Money, Credit and Banking*, *42*(1), 1-32.

Nazer, Y., and Love. A. (2020), *The Impacts of New Technology on Market Power: The Case of the US Petroleum Industry*. Paper presented at the mathematical Institute of Oxford University

Pevzner, M., Xie, F., & Xin, X. (2015). When firms talk, do investors listen? The role of trust in stock market reactions to corporate earnings announcements. *Journal of Financial Economics*, *117*(1), 190-223.

Rich, R. W., Raymond, J. E., & Butler, J. S. (1992). The relationship between forecast dispersion and forecast uncertainty: Evidence from a survey data—arch model. *Journal of Applied Econometrics*, *7*(2), 131-148.

Rösch, A., & Schmidbauer, H. (2009, July). Action Selection in Customer Value Optimization: An Approach Based on Covariate-Dependent Markov Decision Processes. In *DMIN* (pp. 189-192).

Ulatowski, R. (2020). OPEC+ as a new governor in Global Energy Governance. *Revista UNISCI*, (53).

Summer, D. A., & Mueller, R. A. (1989). Are harvest forecasts news? USDA announcements and futures market reactions. *American Journal of Agricultural Economics*, *71*(1), 1-8.

Zhang, S., Andrews-Speed, P., Zhao, X., & He, Y. (2013). Interactions between renewable energy policy and renewable energy industrial policy: A critical analysis of China's policy approach to renewable energies. *Energy Policy*, *62*, 342-353.

Data Appendix

The following appendix describes the data sources used in our study.

OPEC members crude oil production and allocation data

In our analysis, we used IEA MODS Platform as a data source. Our crude oil production data ranged from 1984 to 2020. The advantage of using the IEA MODS platform for crude oil production lies in its consistency and richness which is relevant to other data sets. For example, the OPEC organization provides oil production data, but only from 2001. Similarly, the U.S., Energy Information Administration (EIA) reports OPEC crude oil production data in three forms (quarterly, monthly, and annual), but only since 1994. However, OPEC's allocation data are taken from OPEC bulletin publications: 1999, 2005, and 2020.

Oil price data

Our study used two sets of oil price data: (a) Brent crude oil price data from 1985 to 2019 obtained from FRED, and (b) "three-month" Brent futures contracts data from 1988 to 2019 obtained from Bloomberg terminal DataStream. We used Brent oil prices, the European benchmark price for crude oil, to minimize the regional bias found in other oil prices, such as WTI and Dubai oil prices.

Macroeconomic data and composite variables

For macroeconomic data, we used the World Economic Outlook (WEO) database, sponsored by the IMF. The WEO data is a world-class database that includes both official data sources and IMF staff surveys and projections of world macroeconomic outlooks.

I. GDP forecast and GDP forecast standard deviation

We have constructed arithmetic weighted average indices for both real-world GDP forecasts and GDP standard deviation from 1989 to 2019 using the IMF consensus forecast database. The index is weighted based on the current percentage change of real GDP and next year's forecast. An arithmetic weighted average of the GDP standard deviation index is derived using the same method. We used both variables in our econometric model to capture macroeconomic sentiment. For example, we used the real GDP forecast index as a proxy for uncertainty, and the real GDP standard deviation forecast index as a confidence interval bound for economic downfall measurements.

II. Global crude oil production and stock shares

We used the IEA MODS Platform database of crude oil production from 1989 to 2019 to calculate OPEC market share: Total OPEC share, OPEC GCC market share (Saudi, UAE, Kuwait) and Saudi Arabia market share. The market share is calculated by dividing each sub-group by global crude oil production. We have also used the total oil stock of OECD countries from 1989 to 2019 as a measure of OPEC policy response to changes in global oil stock.

III. Macroeconomic variables

We have used several macroeconomic variables obtained from FRED in our multinomial logic approach to capture macroeconomic sentiment. To capture the effects of monetary policy on OPEC's decisions, for example, three-month U.S. Treasury bills and AAA Moody's Corporate Bond Yield are used. A trade-weighted index of major currencies and goods is also included to measure the impact of the U.S. exchange rate on oil trade.

Text Analysis: Approach

To set up the stage, we estimated the semantic similarity between documents using Python Bag of Words Approach. We create $M \times N$ word count matrix, where M is collection of OPEC statements and, N is list of words contained in a collection of documents. Each row of the matrix corresponds to a single OPEC statement in which each column corresponds to one of the N unique words contained in a collection of statements.

Similarity between two documents is defined as the cosine angle between two row vectors

(8) $$\text{Similarity} = \cos(\theta) = \frac{A \cdot B}{||A|| \cdot ||B||} = \frac{\sum_{i=1}^{n} A_i \cdot B_i}{\sqrt{\sum_{i=1}^{n} A_i^{\,2}} \sqrt{\sum_{i=1}^{n} B_i^{\,2}}}$$

where *n* is the number of unique terms; A and B represent two document vectors; *Ai* and *Bi* represent the number of times that word *i* occurs in document *A* and *B*, respectively.

Preparation of text

First, remove stop words that are commonly used in the English language and provide little semantic content, including pronouns, articles, conjunctions, dates, numbers, etc.
Next, stem all words to their root forms, meaning for example, the three words - agreed, agreeing and agreeable are all shortened to the same root form agree. Root forms are created by removing the suffixes or prefixes used with a word. Lastly, apply a standard weighting scheme know as *term frequency-inverse document frequency* (TF-IDF) to the now smaller term-document matrix. This procedure gives a lower weight to terms that occur in many documents, i.e. terms that are less important over the entire sample of OPEC statements.

Next, we sign a weight for most frequent words that have been used in statements by applying TF-IDF to capture each word contribution in statements see (Fraiberger, Lee, Puy & Rancier 2018).

(9) $$w_{ij} = \log\left(\frac{M}{N_i}\right) + 1$$

w_{ij} is frequency weight for each *selected* word, M is the number of OPEC statements and N_i is the number of articles in which word i is present in j statement. Hence, the higher weighting gives more weight to words that appear more rarely across statements. The effect of adding "1" to the IDF in the equation above is that terms with zero IDF, i.e., terms that occur in all documents in a training set, will not be entirely ignored.

Table 7: OPEC meetings' announcements

Table shows all OPEC events between period 1987 to 2019. This includes OPEC intentions (cut/boost/neutral), Brent oil average price return before and after announcement date and the average impact of meetings on the market.

Date	Decision	Average Before Meeting	Average After Meeting	Average Price Change Difference
1987-06-29	Boost	-0.013	0.017	0.029
1987-12-14	Cut	0.053	-0.020	-0.073
1988-06-14	Neutral	0.020	-0.047	-0.067
1988-11-28	Boost	-0.131	0.003	0.134
1989-06-07	Boost	-0.003	-0.058	-0.055
1989-11-28	Boost	0.022	0.047	0.025
1990-07-27	Boost	-0.061	0.220	0.280
1990-12-13	Neutral	0.081	-0.006	-0.087
1991-03-12	Cut	0.038	0.027	-0.011
1991-06-04	Neutral	0.012	-0.037	-0.049
1991-09-25	Boost	-0.012	0.048	0.060
1991-11-27	Cut	0.056	-0.032	-0.088
1992-02-17	Cut	0.047	-0.008	-0.055
1992-05-22	Neutral	0.003	0.068	0.065
1992-11-27	Boost	0.006	-0.041	-0.047
1993-02-16	Cut	0.028	0.045	0.017
1993-06-10	Neutral	0.036	-0.022	-0.057
1993-09-29	Boost	-0.039	0.035	0.074
1993-11-24	Neutral	0.011	-0.076	-0.087
1994-03-28	Neutral	0.041	0.036	-0.004
1994-06-16	Neutral	-0.039	0.028	0.068
1994-11-22	Neutral	-0.004	-0.034	-0.031
1995-06-20	Neutral	0.046	-0.032	-0.078
1995-11-22	Neutral	-0.009	0.021	0.029
1996-06-07	Boost	0.019	-0.002	-0.022
1996-11-29	Neutral	-0.001	0.024	0.025
1997-06-26	Neutral	-0.020	0.033	0.054
1997-12-01	Boost	-0.090	-0.074	0.016
1998-03-30	Cut	-0.090	-0.074	0.016
1998-06-24	Cut	-0.084	-0.056	0.028
1998-11-25	Cut	0.033	-0.065	-0.098
1999-03-23	Cut	-0.104	0.037	0.141
1999-09-22	Neutral	0.008	0.029	0.021
2000-03-29	Cut	0.102	-0.044	-0.146
2000-06-21	Boost	-0.052	0.008	0.061
2000-09-11	Boost	-0.048	-0.135	-0.087
2000-11-13	Neutral	0.021	0.095	0.074
2001-01-03	Cut	0.080	0.024	-0.057
2001-03-19	Cut	0.021	0.095	0.074
2001-06-05	Neutral	-0.005	-0.034	-0.030
2001-07-03	Neutral	0.041	-0.037	-0.078
2001-09-27	Neutral	0.158	-0.018	-0.177
2001-11-14	Cut	0.037	-0.028	-0.065
2002-03-15	Neutral	-0.063	0.039	0.101
2002-06-26	Neutral	-0.023	0.030	0.053
2002-09-19	Neutral	-0.009	0.019	0.027
2002-12-12	Cut	0.009	0.037	0.028
2003-01-13	Boost	-0.002	-0.161	-0.160
2003-03-11	Neutral	-0.052	-0.065	-0.013
2003-06-11	Neutral	-0.001	0.052	0.053
2003-07-31	Neutral	-0.016	0.063	0.078
2003-09-24	Cut	-0.012	0.037	0.049
2003-12-04	Neutral	-0.004	0.040	0.045
2004-02-10	Cut	-0.004	0.040	0.045
2004-03-31	Neutral	0.044	0.022	-0.022
2004-06-03	Boost	0.048	-0.027	-0.076
2004-09-15	Boost	-0.029	0.075	0.104
2004-12-10	Cut	0.077	0.082	0.005
2005-01-31	Neutral	0.020	-0.017	-0.037
2005-03-16	Boost	-0.036	-0.022	0.014
2005-06-15	Boost	-0.047	0.045	0.092
2005-09-20	Neutral	-0.010	-0.016	-0.006
2005-12-12	Neutral	-0.046	0.003	0.049
2006-01-31	Neutral	0.009	-0.033	-0.043
2006-03-08	Neutral	0.032	0.049	0.018
2006-06-01	Neutral	-0.008	-0.024	-0.016
2006-09-11	Cut	0.079	-0.037	-0.115
2006-12-14	Cut	0.007	-0.033	-0.040
2007-03-15	Neutral	-0.005	0.027	0.032
2007-09-11	Boost	-0.051	0.019	0.070
2007-12-05	Neutral	0.016	-0.007	-0.023
2008-02-01	Neutral	-0.018	0.015	0.033
2008-03-05	Neutral	-0.045	0.015	0.060
2008-09-10	Neutral	0.107	-0.016	-0.123
2008-10-24	Cut	0.082	-0.080	-0.162
2008-12-17	Cut	0.004	-0.108	-0.112
2009-03-15	Neutral	-0.004	0.107	0.110
2009-05-28	Neutral	-0.094	0.072	0.166
2009-09-10	Neutral	0.007	-0.015	-0.022
2009-12-22	Neutral	-0.025	0.060	0.085
2010-03-17	Neutral	-0.019	-0.012	0.007
2010-10-14	Neutral	-0.008	-0.021	-0.012
2010-12-11	Neutral	-0.014	0.027	0.041
2011-06-08	Neutral	-0.032	-0.027	0.005
2011-12-14	Neutral	0.035	0.015	-0.020
2012-06-14	Neutral	0.030	-0.044	-0.075
2012-12-12	Neutral	-0.009	-0.003	0.006
2013-05-31	Neutral	0.022	0.029	0.008
2013-12-04	Neutral	-0.024	-0.030	-0.006
2014-06-11	Neutral	-0.004	0.034	0.038
2014-11-27	Neutral	0.082	-0.080	-0.162
2015-06-05	Neutral	0.041	0.024	-0.017
2015-12-04	Neutral	0.038	-0.099	-0.137
2016-06-02	Neutral	-0.009	-0.009	0.000
2016-09-28	Cut	0.011	0.085	0.074
2016-11-30	Cut	-0.050	0.092	0.141
2017-05-25	Neutral	-0.018	-0.066	-0.048
2017-12-01	Neutral	-0.029	-0.012	0.017
2018-06-22	Boost	0.010	0.030	0.020
2018-12-07	Cut	-0.040	-0.089	-0.049
2019-07-01	Neutral	-0.001	0.001	0.001

** Average price return is based on natural log*

Table 8: OPEC events analysis (1989-2019)

OPEC Decision		Number of Events	Price Return Before Announcement			Price Return After Announcement			Difference of Price Return			Volatility		
			Average	Max	Min	Average	Max	Min	Average	Max	Min	Average	Max	Min
Cut	1980	1	0.053	0.053	0.053	-0.024	-0.024	-0.024	-0.076	-0.076	-0.076	0.042	0.042	0.042
Cut	1990	8	-0.011	0.056	-0.104	-0.018	0.046	-0.077	-0.007	0.150	-0.098	-0.018	0.012	-0.084
Cut	2000	12	0.035	0.134	-0.051	0.006	0.095	-0.150	-0.029	0.146	-0.154	-0.004	0.025	-0.042
Cut	2010	3	-0.026	0.011	-0.050	0.030	0.092	-0.088	0.056	0.141	-0.048	0.010	0.033	-0.010
Cut	All	24	0.013	0.134	-0.104	0.000	0.095	-0.150	-0.013	0.150	-0.154	-0.005	0.042	-0.084
Boost	1980	4	-0.031	0.022	-0.131	0.002	0.047	-0.058	0.033	0.134	-0.055	-0.001	0.018	-0.035
Boost	1990	6	-0.007	0.060	-0.061	0.034	0.220	-0.041	0.041	0.280	-0.092	0.012	0.089	-0.022
Boost	2000	8	-0.026	0.048	-0.052	0.000	0.075	-0.135	0.025	0.104	-0.087	0.000	0.030	-0.023
Boost	2010	1	0.010	0.010	0.010	0.030	0.030	0.030	0.020	0.020	0.020	0.006	0.006	0.006
Boost	All	19	-0.019	0.060	-0.131	0.013	0.220	-0.135	0.032	0.280	-0.092	0.004	0.089	-0.035
Neutral	1980	1	0.020	0.020	0.020	-0.047	-0.047	-0.047	-0.067	-0.067	-0.067	0.005	0.005	0.005
Neutral	1990	13	0.009	0.081	-0.039	-0.003	0.061	-0.076	-0.012	0.068	-0.087	0.000	0.025	-0.067
Neutral	2000	27	0.001	0.158	-0.091	0.007	0.107	-0.161	0.006	0.162	-0.177	0.003	0.086	-0.122
Neutral	2010	17	0.000	0.038	-0.029	-0.020	0.034	-0.140	-0.020	0.040	-0.148	0.005	0.038	-0.012
Neutral	all	58	0.003	0.158	-0.091	-0.004	0.107	-0.161	-0.007	0.162	-0.177	0.003	0.086	-0.122
All	1980	6	-0.008	0.053	-0.131	-0.010	0.047	-0.058	-0.002	0.134	-0.076	0.007	0.042	-0.035
All	1990	27	0.000	0.081	-0.104	0.001	0.220	-0.077	0.001	0.280	-0.098	-0.003	0.089	-0.084
All	2000	47	0.005	0.158	-0.091	0.005	0.107	-0.161	0.000	0.162	-0.177	0.001	0.086	-0.122
All	2010	21	-0.003	0.038	-0.050	-0.011	0.092	-0.140	-0.008	0.141	-0.148	0.006	0.038	-0.012
All	all	101	0.001	0.158	-0.131	0.000	0.220	-0.161	-0.001	0.280	-0.177	0.001	0.089	-0.122

Source: IMF staff calculation.
Note: The number of events refer to OPEC meetings by decade, including all decision type. However, the category "All" captures all meetings' decisions with no distinction among decision types.

Table 9: Expected vs. unexpected impact of OPEC decisions

Cut (R>0)

Date	3-days Cumulative Return	11-days Cumulative Return
2016-11-30	9.33%	9.15%
1991-03-12	7.07%	2.72%
2016-09-28	6.26%	8.54%
2001-01-03	5.22%	6.41%
2002-12-12	4.45%	9.82%
2004-12-10	3.02%	8.20%
2003-09-24	1.72%	6.28%
2000-03-29	1.70%	-4.42%
2004-02-10	1.40%	4.03%
1991-11-27	1.19%	-3.21%
2001-03-19	1.03%	2.35%
2008-10-24	0.20%	-1.43%
1992-02-17	0.19%	-0.83%

Cut (R<0)

Date	3-days Cumulative Return	11-days Cumulative Return
1999-03-23	-0.21%	4.50%
2006-12-14	-0.34%	-2.33%
1993-02-16	-1.00%	2.30%
1998-11-25	-1.46%	-6.54%
2006-09-11	-1.60%	-3.66%
2018-12-07	-2.83%	-8.86%
1998-06-24	-4.61%	-5.62%
1998-03-30	-4.96%	-7.82%
2008-12-17	-6.38%	-13.56%
1987-12-14	-6.70%	-2.42%
2001-11-14	-12.10%	-2.75%

Boost (R<0)

Date	3-days Cumulative Return	11-days Cumulative Return
1987-06-29	-0.25%	1.67%
1996-06-07	-0.38%	-0.23%
1997-12-01	-0.65%	-3.22%
1988-11-28	-1.53%	0.26%
2004-06-03	-1.64%	-2.74%
1992-11-27	-1.71%	-4.11%
1989-06-07	-2.85%	-5.83%
2000-09-11	-14.50%	-13.48%

Boost (R>0)

Date	3-days Cumulative Return	11-days Cumulative Return
2003-01-13	4.28%	3.70%
2005-06-15	3.58%	4.53%
1991-09-25	3.11%	4.83%
2005-03-16	2.39%	-2.58%
2007-09-11	1.98%	1.94%
1990-07-27	1.80%	21.98%
1993-09-29	1.71%	1.25%
1989-11-28	1.12%	4.72%
2004-09-15	0.96%	7.51%
2018-06-22	0.65%	2.96%
2000-06-21	0.43%	0.83%

Neutral (P>0)

Date	3-days Cumulative Return	11-days Cumulative Return
1992-05-22	5.08%	6.51%
2009-12-22	4.84%	7.76%
2009-03-15	4.70%	10.65%
1999-09-22	4.63%	2.89%
2009-05-28	4.52%	7.15%
2003-07-31	4.39%	4.05%
2015-06-05	4.38%	2.36%
1997-06-26	4.15%	3.88%
2005-12-12	3.84%	0.33%
2000-11-13	3.55%	2.75%
2008-03-05	3.44%	4.22%
1996-11-29	3.27%	2.42%
1994-06-16	2.91%	2.83%
2002-06-26	2.81%	2.98%
2014-06-11	2.77%	3.37%
2002-09-19	2.41%	1.88%
2003-12-04	2.12%	3.74%
2006-03-08	2.01%	4.92%
2001-07-03	1.97%	-3.72%
2013-05-31	1.93%	2.90%
2002-03-15	1.91%	3.89%
2005-09-20	1.13%	-1.59%
2006-01-31	1.08%	-3.31%
2011-06-08	1.08%	-2.70%
1990-12-13	0.95%	-0.48%
2010-12-11	0.68%	2.09%
1995-11-22	0.61%	2.06%
2007-03-15	0.18%	4.67%
2016-06-02	0.03%	-0.87%

Neutral (P<0)

Date	3-days Cumulative Return	11-days Cumulative Return
2001-09-27	-0.06%	-1.8%
2006-06-01	-0.25%	-2.4%
2012-12-12	-0.52%	-0.3%
2012-06-14	-0.66%	-4.4%
2014-11-27	-0.83%	-6.6%
2005-01-31	-0.85%	-1.7%
2011-12-14	-1.30%	1.2%
1994-11-22	-1.50%	-3.4%
2008-02-01	-1.78%	1.5%
2010-03-17	-1.80%	-1.2%
2001-06-05	-1.83%	-3.4%
2013-12-04	-1.84%	-3.0%
2017-05-25	-1.95%	-6.6%
1988-06-14	-2.00%	-4.7%
2004-03-31	-2.02%	2.2%
2010-10-14	-2.13%	-2.1%
2009-09-10	-2.30%	-1.5%
2017-12-01	-2.39%	-1.2%
2008-09-10	-2.55%	-1.6%
2003-03-11	-2.61%	-16.1%
1991-06-04	-2.79%	-4.5%
2019-07-01	-2.82%	0.1%
2007-12-05	-2.93%	-0.007
1995-06-20	-2.97%	-0.032
1994-03-28	-3.43%	0.026
1993-06-10	-3.91%	-0.051
2003-06-11	-4.17%	-0.065
2015-12-04	-5.08%	-0.099
1993-11-24	-6.16%	-0.076

Note: R is the oil price cumulative return in the [3] and [11] days after the conclusion of the meeting, If the decision was unexpected a cut implies R>0, a boost R<0 , and no change R=0. This is what we have so far OPEC's meetings are further split into regular (ordinary) and non-regular (extraordinary) meetings. The former has a fixed schedule while the latter are usually called in response to exceptional circumstances (e.g., after the 9/11 terrorist attack). Out of 101 meetings 30 are non-regular meetings. Regular OPEC meetings usually last two days.