DOES OPEC ANNOUNCEMENT POLICY MATTER IN THE CREATION OF CRUDE OIL PRICE VOLATILITY?

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Abstract

Several times a year, OPEC hosts conferences with its members to review oil fundamentals and decide on production quota adjustments. The organization meets behind closed doors, but the opening meeting is open to the press and usually fuels market speculation on which agreement concerning oil production levels (maintain, increase, or cut) will be arrived at. The decisions taken are formally announced in a press release at the end of the conference. The purpose of our investigation is to assess the impact of OPEC announcements on the tail behavior of the distribution of crude oil price changes before and after an OPEC announcement, and in the absence of an announcement. The tail behavior is characterized by fitting a generalized Pareto distribution to return data in these three situations. We find that the pre-announcement situation is tense in the sense that the upper tail of the return distribution is heavy (thus making substantial price increases more likely), while the situation is relaxed after an announcement in the sense that the upper tail is no longer heavy. The lower tail of the return distribution is found to behave in the opposite way.

Key words: Crude oil price volatility; generalized Pareto distribution; OPEC desicions; WTI crude oil price

1 Introduction

Among the driving forces behind crude oil price fluctuations, there use to been brought forth economic factors, geopolitical tensions, uncertainty over supply and demand, and speculative flows. At the same time the OPEC's interests are questioned: "OPEC's policies will ensure oil price volatility", instead of eliminating "harmful" fluctuations, an FT article commented on the cartel's first scheduled meeting after crude oil prices had hit the $100-a-barrel level for the first time[1].

OPEC hosts (mostly scheduled) meetings several times a year in order to agree on further oil production policies. These meetings are supposed to be non-public, but on the last day announcements are made concerning an overall production ceiling and individual quotas of its

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[1]Financial Times, 2008-01-30.

members; see [4]. Decisions are rather compromises, [2] argues, which leads to a "channel through which the OPEC can induce volatility".

Percentage changes of average crude oil prices before and after OPEC announcements were compared by [8]. They concluded that announcements play a diminished role in the world oil market after 1985.

Covering the period from 1982 through 2008, [3] analyzed whether there are differences between no-change, increase, or cut decisions of the cartel with respect to its impact on prices of crude oil diversified into price regimes, light and heavy, OPEC and non-OPEC grades. In their approach they considered returns surrounding announcements and accumulated deviations from average returns relating to preceding announcement-free periods. They observed after-announcement effects, varying in strength and direction, depending on the type of decision and on the price regime. Results related to no-change announcements were mostly found insignificant. These observations were made likewise for OPEC and non-OPEC grades, light and heavy grades.

The present study investigates the tails of the distribution of daily oil price changes. This complements our earlier, GARCH based, study insofar as upper and lower tails of the return distribution can be analyzed separately and explicitly, thus revealing possible asymmetries around OPEC announcements.

Our hypotheses are:

- Tails will be heavier before/after announcements than elsewhere.
- There is a stronger reaction before announcements than afterward.
- The character of tails depends on the type of announcements.
- (something about asymmetry — lower vs. upper tail)

2 Data

The time series of WTI prices (in USD/barrel) and price changes in percent are shown in Figure 1, the vertical lines located at OPEC announcement dates, with lengths indicating the kind of decision made concerning the production level (maintain, increase, or cut the current level).[2] There were 88 announcements in the time period we consider (January 1986 through September 2009, 5990 data points): 21 cut / 24 increase / 43 maintain decisions were made. The dates of announcements are listed in the Appendix, together with the kind of announcement made. The plot of daily returns also shows the 20% and 80% quantiles ($q_{0.2} = -1.578\%$, $q_{0.8} = +1.686\%$), which define the threshold for our investigation of tails. The intensity with which this threshold is exceeded is not constant, as a visual inspection of the plot reveals. This topic will be discussed in Section 4 below.

[2]The series of daily prices is available from the website of the Energy Information Administration: http://www.eia.doe.gov. Information on OPEC meetings and announcements is published on the OPEC website: http://opec.org.

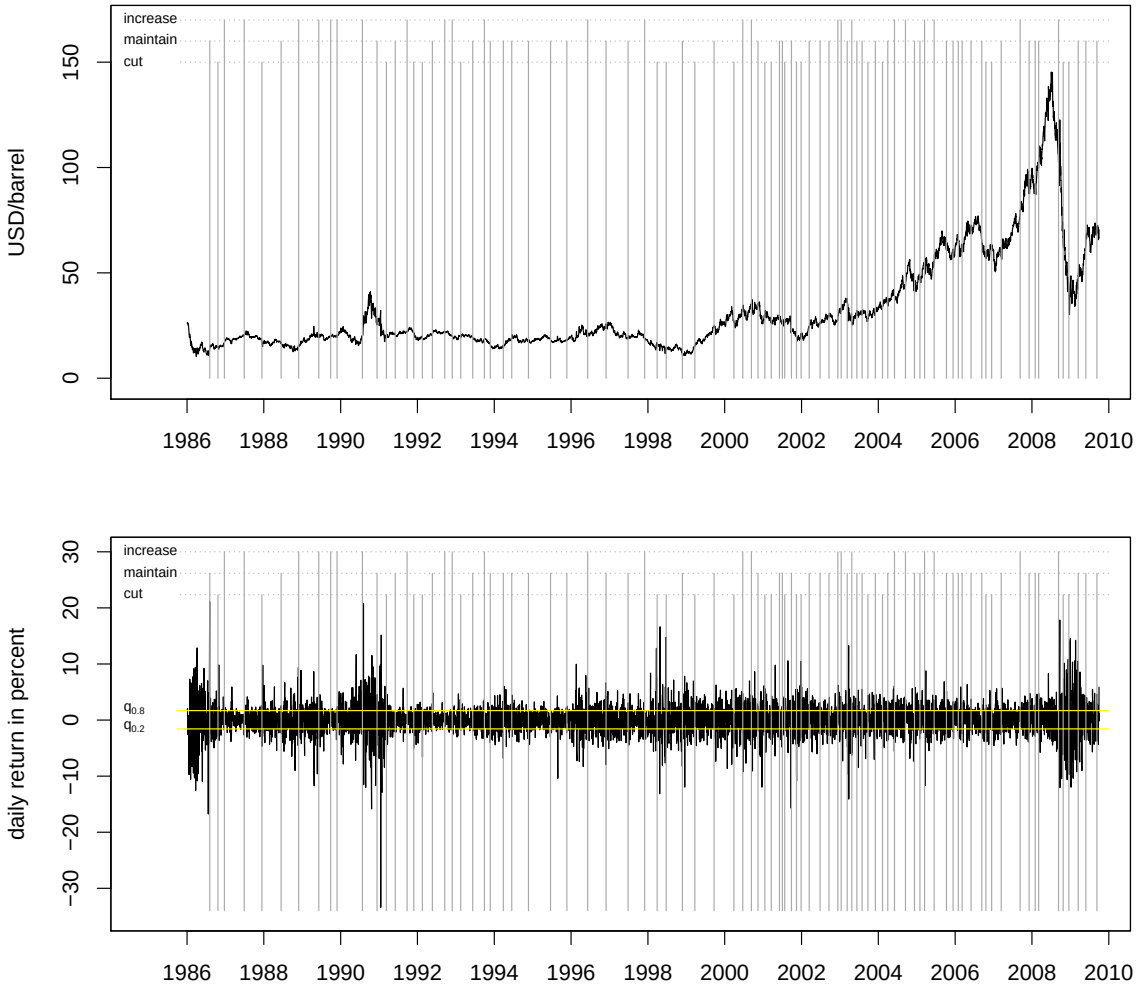

Figure 1: WTI prices / price changes, OPEC announcements

3 Impact of announcements: A GARCH approach

The model is:

$$r_t = c + \sum_{s \geq 1} a_s r_{t-s} + \sum_i b_i d_{it} + \epsilon_t, \tag{1}$$

$$\epsilon_t = \nu_t \cdot \sqrt{h_t}, \tag{2}$$

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta h_{t-1} + \sum_i \gamma_i d_{it}. \tag{3}$$

Here, (r_t) is the series of daily returns on WTI crude oil prices, (d_{it}) is a series of (modified) dummy variables for OPEC announcements of kind i (cut, increase, maintain), (ν_t) is Gaussian white noise with $\mathrm{var}(\nu_t) = 1$, and b_i and γ_i are parameters quantifying the impact of an announcement of kind i.

The original dummy variables are set to 1 on the day of the respective announcement. In order to account for anticipation or aftereffect of an announcement, a dummy variable is modified so that it may equal 1 some days before and/or after the day of the announcement, and it may gradually grow from 0 to 1 (reflecting increasing upcoming effect) or gradually die down from 1 to 0 (reflecting vanishing impact).

The modified dummy variables of the optimal model are displayed in Figure 2, where t_a

designates the day of an announcement. The structure of modification justifies our definition (see below) of the time periods *before* and *after* an announcement, both of which are chosen to extend over five days. This is in line with the structure of impact found for the regression/GARCH model (Equations (1)–(3)), which has a maximum length of slightly more than five days.

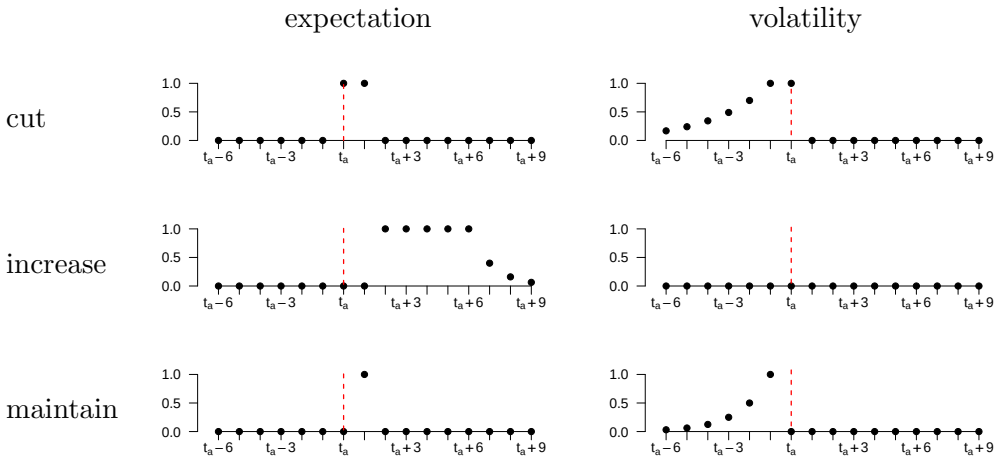

Figure 2: Optimal modifications of dummy variables, regression and GARCH model

4 Return exceedances

Return exceedances constitute the empirical basis for investigating the tails of the distribution of daily returns. A lower and an upper threshold need to be determined for the definition of a return exceedance (the event). The difference between the return on a day when an exceedance happened and the threshold is called the excess, and an extreme-value distribution can be used as a probabilistic model to understand tail behavior. In the present study, we use the empirical 20% (80%) quantile to determine the lower (upper, respectively) tail of the return distribution; see also the discussion in Schmidbauer and Rösch [6].

4.1 Some empirical facts about return exceedances

Figure 3 reveals that the share of observed returns below the 20% quantile or above the 80% quantile per year is not constant (the weighted arithmetic means of both series will equal 0.2), reflecting the heteroskedasticity of the time series: years 1987, 1992 and 1995 display relative tranquility, while crude oil prices were more volatile in 1986, 1990, 1999, and 2008. In addition, asymmetry can be observed insofar as the share of lower exceedances need not be close to the share of upper exceedances: the greatest discrepancies were observed in 1999 (upper higher than lower, a consequence of the crude oil price increase observed in that year) and 2008 (lower higher than upper, a consequence of the sharp price decline after the record high of almost USD 150/barrel in early July of 2008). The amount of heteroskedasticity does, however, not go so far as to leave some years without any exceedances.

Is the occurrence of return exceedances linked to time periods shortly before or after OPEC announces a decision? A χ^2 test using the data in the contingency table of Table 1 does not lead to a rejection of the null hypothesis of independence ($\chi^2 = 7.4329$ at 4 df; p-value: 0.11.) It is therefore legitimate to determine the 20% and 80% quantiles from *all* returns, classifying returns into "before", "after", "elsewhere", and analyze distribution tails of each segment separately —

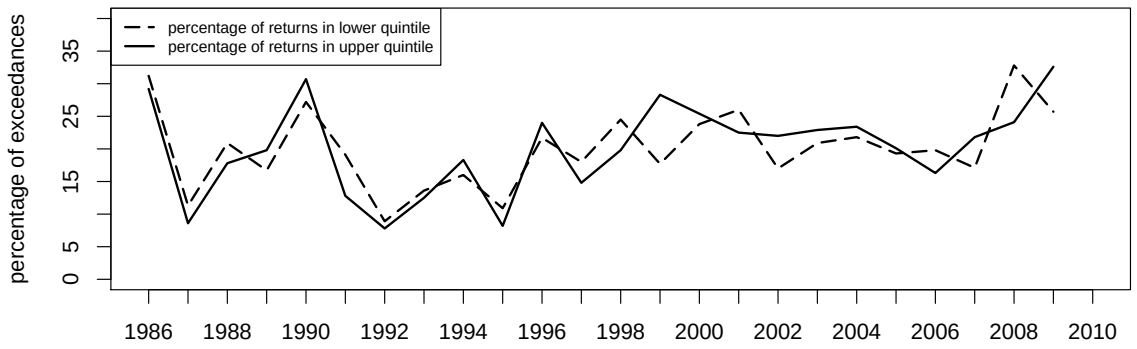

Figure 3: Annual percentage of lower and upper threshold exceedances

there is no evidence that this procedure cuts off a share different from a fifth from either side during decision periods.

	$< q_{20\%}$	between	$> q_{80\%}$
5, ..., 1 day(s) before ann.	222	560	179
0, ..., 5 day(s) after ann.	177	525	178
elsewhere	819	2567	861

Table 1: Location of return exceedances and OPEC announcements

4.2 Modeling return exceedances: The generalized Pareto distribution

The GPD is a model for excesses of a random variable. The rationale behind using the GPD is a limit theorem which states[3]: Let $R_1, \ldots, R_n$ be iid random variables, and let R be distributed like R_i. Then, for large n and u, there are ξ and σ such that the distribution function of the excess

$$R - u, \quad \text{conditional on} \quad R > u,$$

is approximately given by

$$F(x;\xi,\sigma) = \begin{cases} 1 - \left(1 + \xi\frac{x}{\sigma}\right)^{-1/\xi} & \text{if } \xi \neq 0, \\ 1 - \exp\left(-\frac{x}{\sigma}\right) & \text{if } \xi = 0. \end{cases}$$

Here, $\sigma > 0$ is a scale parameter; it depends on the threshold and on the probability density function of R_i. The shape parameter ξ is called the tail index, since it characterizes the tail of the density function:

- The case $\xi > 0$ corresponds to fat-tailed distributions; in this case, the GPD reduces to the Pareto distribution.
- The case $\xi = 0$ corresponds to thin-tailed distributions; the GPD then reduces to the exponential distribution with mean σ.
- The case $\xi < 0$ corresponds to distributions with no tail (i.e. finite distributions). When $\xi = -1$, the GPD becomes a uniform distribution on the interval $[0, \sigma]$.

[3]For example, see Coles [1].

	lower tail (20%)					upper tail (80%)				
decision	ξ	se	t value	p value	obs.	ξ	se	t value	p value	obs.
situation **without** announcement:										
—	0.156	0.035	4.461	0.000	1016	0.170	0.036	4.693	0.000	1008
situation **before** an announcement:										
any	0.169	0.117	1.446	0.148	93	0.362	0.150	2.412	0.016	83
cut	−0.170	0.248	−0.684	0.494	27	0.125	0.355	0.351	0.725	22
increase	−0.280	0.202	−1.385	0.166	24	0.020	0.273	0.074	0.941	22
maintain	0.396	0.219	1.805	0.071	42	0.371	0.187	1.988	0.047	39
situation **after** an announcement:										
any	0.297	0.133	2.238	0.025	109	−0.082	0.085	−0.963	0.336	127
cut	0.163	0.224	0.725	0.469	40	−0.052	0.246	−0.212	0.832	29
increase	0.639	0.408	1.568	0.117	22	0.082	0.213	0.386	0.699	29
maintain	0.150	0.160	0.942	0.346	47	−0.305	0.106	−2.872	0.004	69

Table 2: Estimation results: lower and upper tail of the return distribution

5 Empirical results

The situation *before* an OPEC announcement is characterized by the parameters ξ of the GPD when fitted to the lower and upper tails of returns observed one to five days prior to a decision (the day of the decision is not included in this period). The very day of a decision, plus the five days following it, is included in the returns to whose lower and upper tails GPDs are fitted characterizing the *after* situation. Estimation results are compiled in Table 2.

OPEC announces the decision made concerning oil production quantities. The GPD was fitted to returns in a decision-specific way ("cut", "increase", "maintain" in Table 2), to returns on days surrounding any OPEC announcements ("any" in Table 2), as well as to returns on all other days ("without announcement" in Table 2).

A test of the null hypothesis $\xi = 0$ (i.e. there is no heavy tail) has a higher power in the case of "any decision", because the number of observations is larger. This case will therefore tend to produce clearer results, and our interpretations of the results in Table 2 begins with this case.

In the case of the situation **before** an announcement, the null hypothesis $\xi = 0$ is not rejected for the lower tail at the 5% level of significance ($\xi = 0.169$, p-value: 0.148, based on 93 observations, which is approximately 20% of $5 \cdot 88$). It is found that the upper tail is heavy, however ($\xi = 0.362$, p-value: 0.016). The situation *before* an announcement can be described as tense in the sense that the *upper* tail is heavy: there is a chance of a substantial price increase.

The situation **after** an announcement (looking at "any" again) is almost reversed, and hence relaxed: For the upper tail, the null hypothesis $\xi = 0$ is not rejected (p-value: 0.336), but the lower tail is heavy ($\xi = 0.297$).

Lower as well as upper tails are heavy in the situation **without** announcement, but there is practically no difference between lower and upper tails — the estimated values of ξ are almost equal.

Figures 4 and Figure 5 show the densities of the GPDs fitted to the lower and upper tails in the three situations considered (shown are the logarithms of the densities). It becomes obvious that the upper tail reacts much more to the specific decision situation than the lower tail. The relaxed condition in the period after an announcement is revealed in Figure 5.

There is some evidence that the tail behavior is decision-specific. In particular, an imminent maintain decision leads to heavy tails at the 10% level of significance, which is not the case for decisions of other kinds. After the announcement of a maintain decision, the ξ of the upper tail of the return distribution is significantly negative.

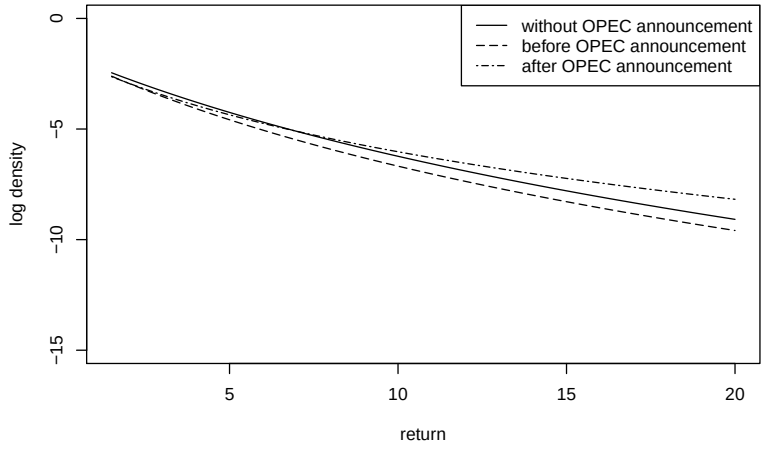

Figure 4: Logarithm of lower tail density, before / after / without OPEC announcements

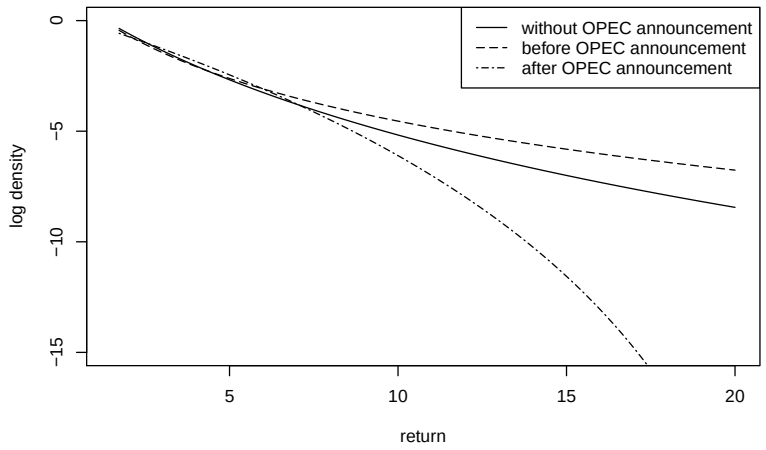

Figure 5: Logarithm of upper tail density, before / after / without OPEC announcements

6 Summary and Conclusions

The focal point of the present study is an analysis of the distributional properties of large daily returns (price changes) on WTI crude oil. Based on a symmetric GARCH approach, it was found earlier (see Schmidbauer and Rösch [7]) that tails of the return distribution are heavier around OPEC announcements than on days without OPEC announcements. Due to its symmetry with respect to the sign of returns, this GARCH approach could not distinguish between upper and lower tails.

The present study treats lower and upper tails separately by fitting generalized Pareto distributions to each tail and three different situations: before and after an OPEC decision is announced, and a situation without OPEC announcement. Based on this approach, we find that tails are generally heavy, and the upper (lower) tail is especially heavy before (after, respectively) OPEC makes an announcement. These findings are in line with our earlier study [7], and they are more specific insofar as we explicitly look into the possibility of large price decreases or increases.

What could not solved with the analysis of the tail behavior is the question whether the weight of tails is decision-specific — this was not possible to answer because the power of the statistical tests involved is too low given the available number of observations. Another question which was not dealt with in the present study is what motivates OPEC to make a certian decision — OPEC decisions are regarded as exogenous.

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