

OPEC NEWS ANNOUNCEMENTS: EFFECTS ON OIL PRICE EXPECTATION AND VOLATILITY *

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Abstract

Several times a year, OPEC hosts conferences among its members to agree on further oil production policies. Prior to OPEC conferences, there is usually rampant speculation about which decision concerning world oil production levels (no change, increase, or cut) will be announced. The purpose of our investigation is to assess the impact of OPEC announcements on expectation and volatility of daily oil price changes (returns).

We modify dummy variables indicating the day of an OPEC announcement to reflect a certain pattern of impact on return expectation and volatility. A combination of regression and GARCH models can then differentiate between pre- and post-announcement effects, and distinguish between the three kinds of OPEC decisions.

We find evidence for pre- (post-) announcement effects on volatility (expectation, resp.), the strength of these effects depending on the kind of decision. Our models also reveal the decision-specific patterns of impact.

Key words: Crude oil price volatility; GARCH; covariates; modified dummy variables; OPEC announcements; WTI crude oil

1 Introduction

During the past two decades, historic lows and highs could be witnessed in the crude oil market. “The world seems to have entered an era of higher crude oil volatility”, Fattouh presumed in his 2005 article on the causes of oil price volatility [4].

Economic factors, geopolitical tensions, and uncertainty over supply and demand have been brought forth to explain these extreme movements in oil prices. Speculation is blamed, notably by the OPEC, while at the same time analysts question the role of the cartel: “OPEC’s policies will ensure oil price volatility”, instead of being a stabilising force, an FT article commented on the cartel’s first scheduled meeting after crude oil prices had hit the \$100-a-barrel level for

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the first time. “Speculative flows accentuate price movements, but the producer group is their prime cause.”¹

To seek causes of volatility on the cartel’s side appears “understandable” to Fattouh [4] in view of the OPEC’s central position in the oil market. The members’ ability to effectively cartelize the oil market is the object of ongoing discussion (cf. [8], [11], [5]). However, price fixing policies could no more be blamed since 1982, when the cartel established a system in which it regulates oil production among its members. Several times a year, the OPEC schedules a conference in order to agree on further oil production policies, based on the cartel’s assessment of the market’s oil demand. The OPEC’s decision usually takes the form of an announcement, setting an overall oil production ceiling for the cartel and individual production quotas for its members; see [9]. As a consequence of the heterogeneity of OPEC members, however, Fattouh [4] argued that agreements would be compromises rather than optimal decisions. This leads to a particular “channel through which the OPEC can induce volatility”: Prior to OPEC conferences, there is usually rampant speculation about which decision on production levels (no change, increase, or cut) the cartel members will agree on.

However, empirical findings on whether crude oil price movements are significantly triggered around OPEC meetings are ambiguous.

There are several studies concerning options on crude oil futures surrounding OPEC meetings. Deaves & Krinsky [2] found that during the 1980s, the oil futures market responded efficiently to OPEC announcements of “good news” in terms of bearish outcomes, but on the average, future prices underreacted to bullish outcomes. The pricing of higher return volatility around the meetings may account for this asymmetry, they argued. According to Wirl & Kujundzic [13] the cartel’s announcements seem to play a much more diminished role in crude oil futures volatility after 1985, while the study by Horan, Peterson & Mahar [6] suggested that implied volatility increases when meetings approach, followed by a decline from the first day. Investigating realized volatility of future prices, Wang, Wu & Yang [12] found no evidence for the importance of OPEC meetings in the daily, but in the weekly horizon. Their findings suggest that OPEC announcements of an increase in production have a positive impact on weekly volatility, but in the pre-meeting period only. There were no significant results with respect to maintain or cut decisions of the cartel.

Lin & Tamvakis [7] analysed 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 increased deviations in the highest price regime prior to the announcement when there were production cuts. This observation was made likewise for OPEC and non-OPEC grades and was explained by insider information leakage.

The purpose of our investigation is to assess whether the following hypotheses can be supported by evidence:

- OPEC announcements impact on crude oil spot prices in terms of expectation as well as volatility.
- There is asymmetry in the sense that the impact on volatility is more pronounced prior to the announcement.
- The extent of impact depends on the type of decision to be announced.

¹Financial Times, 2008-01-30.

In our study, we consider daily price changes of WTI, one of the benchmark crudes, and OPEC meetings since 1986. The idea that announcements may affect expectation of price changes as well as volatility leads us to a GARCH specification with covariates. The covariates are dummy variables which indicate the day of the announcement and allow for modeling different patterns of anticipation or aftereffects of the cartel’s decision (no change, increase, or cut of production level).

All computations were carried out in R [10]. — This paper is organized as follows. Section 2 introduces the data which we use in our study. The GARCH specification, and how we proceed to model possible effects of announcements are provided in Sections 3 and 4. Empirical results are presented in Section 5. Finally, Section 6 gives a summary and some conclusions.

2 Data

The time series of WTI prices (in USD/barrel) and price changes in percent are shown in Figure 1, the vertical lines indicating the dates of OPEC announcements: black – maintain, green – increase, red – cut the current production 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.

3 The Model

The idea of this investigation is that an OPEC announcement can have an effect on the expectation of the return on crude oil, as well as on its volatility. This leads us to using the following model:³

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

$$\epsilon_t = \nu_t \cdot \sqrt{h_t}, \quad (2)$$

$$h_t = \alpha_0 + \alpha_1 \epsilon_{t-1}^2 + \beta h_{t-1} + \sum_i \gamma_i d_{it}, \quad (3)$$

where (r_t) is the series of daily returns in percent on the WTI crude oil price, and (d_{it}) is the series of (modified, see Section 4 below) dummy variables for announcements of kind i . Equation (1) specifies the conditional expectation of r_t , the lagged values of r_t on the right side of the equation accounting for autocorrelation in the (r_t) series, and with the dummy variables as regressors. Equations (2) and (3) specify the conditional variance of r_t , where (ν_t) is Gaussian white noise with $\text{var}(\nu_t) = 1$. The conditional variance of r_t is also allowed to depend on the dummy variables. The dummy variables are:

$$\begin{aligned} d_{\text{cut},t} &= \begin{cases} 1 & \text{production cut announced on day } t, \\ 0 & \text{no such OPEC announcement on day } t, \end{cases} \\ d_{\text{increase},t} &= \begin{cases} 1 & \text{production increase announced on day } t, \\ 0 & \text{no such OPEC announcement on day } t, \end{cases} \\ d_{\text{maintain},t} &= \begin{cases} 1 & \text{announcement of unchanged production level on day } t, \\ 0 & \text{no such OPEC announcement on day } t. \end{cases} \end{aligned} \quad (4)$$

²The 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>.

³Equation (3) is the conditional variance specification of a GARCH(1,1) process, see Engle [3], Bollerslev [1], with dummy variables added on.

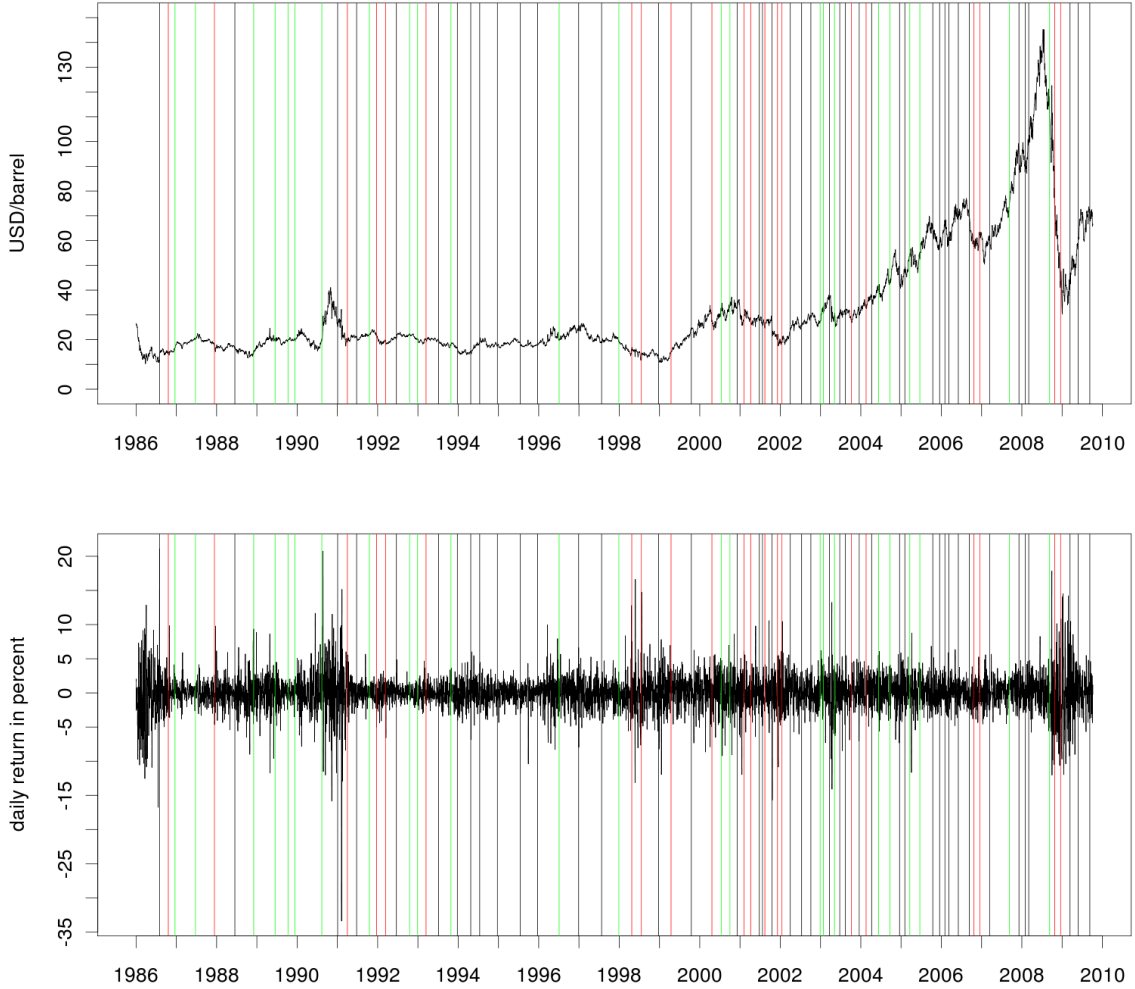


Figure 1: WTI prices / price changes, OPEC announcements

4 Modeling the Effects of Announcements

The unmodified dummy variables, as defined in (4), can only account for an instantaneous effect of an OPEC announcement, that is, an effect which acts on expectation and volatility only on the very day the announcement is made. The dummy variables are therefore modified in a certain way in order to account for the impact in a more differentiated way. We distinguish modifications to capture (i) the way an OPEC announcement is anticipated, (ii) the aftereffect of an announcement. For the latter, we use three operations, which we call A1, A2, and A3 (“A” stands for *after*):

A1: Re-location of 1s: Given a sequence $d = (d_t)$, we define a sequence in which the the position of 1s is shifted by s_1 days (L designates the lag operator):

$$d^{(1)} = L^{+s_1}d, \quad s_1 \in \mathbb{N}$$

Example: Let $d = (0, 0, 1, 0, 0, 0, 0, 0, 0, 0)$ and $s_1 = 1$. Then $d^{(1)} = (0, 0, 0, 1, 0, 0, 0, 0, 0, 0)$.

A2: Duplication of 1s: The sequence $d^{(1)} = (d_t^{(1)})$ is further modified by substituting s_2 1s in a row, after each 1 in $(d_t^{(1)})$:

$$d^{(2)} = \sum_{i=1}^{s_2} L^{i-1}d^{(1)}, \quad s_2 \in \mathbb{N},$$

where the sum is defined element-wise. In all our examples, it is assumed that s_2 is smaller than the minimum distance of 1s in the original sequence. If $s_2 = 1$, this operation will leave the series unaltered, that is, $d^{(2)} \equiv d^{(1)}$.

Example: Let $d^{(1)}$ be as before, and $s_2 = 2$. Then $d^{(2)} = (0, 0, 0, 1, 1, 0, 0, 0, 0, 0)$.

A3: Adjoining a geometric sequence: After each 1 followed by a 0 in $d^{(2)}$, substitute a finite geometric sequence with coefficient s_3 to replace the 0s:

$$d^{(3)} = d^{(2)} + \sum_{i=1}^k s_3^i L^{s_2-1+i} d^{(1)}, \quad s_3 \in (0, 1), \quad k = \min\{m \geq 1 : s_3^{m+1} < 0.1\}.$$

Example: With $d^{(2)}$ as before and $s_3 = \frac{1}{2}$, $d^{(3)} = (0, 0, 0, 1, 1, \frac{1}{2}, \frac{1}{4}, \frac{1}{8}, 0, 0)$.

These three steps are summarized in the notation $\text{sc.after} = (s_1, s_2, s_3)$, and we call this a scenario. An example is shown in the left-hand plot of Figure 2. There was an OPEC announcement on day t_a , that is, $d_{t_a} = 1$ for the original sequence. The plot shows the modified variable with $s_1 = 1$, $s_2 = 3$, and $s_3 = 0.8$.

In a similar way, a sequence $d = (d_t)$ can be modified to reflect the anticipation of an announcement. The duplication of 1s will then be in reverse direction, the geometric sequence is adjoined backward, and we write $\text{sc.before} = (s_1, s_2, s_3)$. An example with $s_1 = 0$, $s_2 = 2$, and $s_3 = 0.7$ is shown in the right-hand plot of Figure 2.

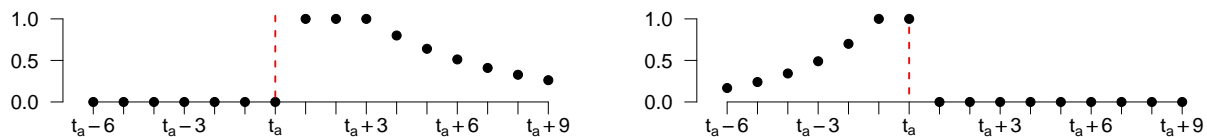


Figure 2: Modified dummy variable

5 Empirical Results

Based on equations (1), (2) and (3), a model for WTI price returns can now be constructed step by step. Optimal scenarios are determined by minimizing the AIC w.r.t. *before* and *after* modifications of dummy variables, defined by the three parameters as laid out in the previous section. The optimal scenarios will result in a model which can best (in the class of models we consider) explain the way OPEC announcements impact expectation and volatility of crude oil price changes.

5.1 Pure regression models

These are models for the expected return only, without considering the volatility.

A. Regression with unmodified dummy variables

It turns out that there is significant autocorrelation in the series of returns only at lags 2 and 5. Substituting all three dummy variables (4) into equation (1) (no matter if they are significant or not), the regression model becomes therefore:

$$r_t = c + a_2 \cdot r_{t-2} + a_5 \cdot r_{t-5} + b_{\text{cut}} \cdot d_{\text{cut},t} + b_{\text{increase}} \cdot d_{\text{increase},t} + b_{\text{maintain}} \cdot d_{\text{maintain},t} + \epsilon_t \quad (5)$$

Estimation results for this model are:⁴

	estimate	std. error	t value	Pr(> t)
c	0.06252	0.03423	1.826	0.068
a_2	-0.04759	0.01290	-3.689	0.000 *
a_5	-0.05499	0.01290	-4.262	0.000 *
b_{cut}	-1.32325	0.57444	-2.304	0.021 *
b_{increase}	0.18612	0.53737	0.346	0.729
b_{maintain}	-0.17767	0.40212	-0.442	0.659

AIC: 28529.80

B. Regression with optimally modified dummy variables

This is again a regression model with daily returns as independent variable, but the dummy variables were modified in such a way that the AIC is minimized:

$$r_t = c + a_2 \cdot r_{t-2} + a_5 \cdot r_{t-5} + b_{\text{cut}} \cdot d_{\text{cut},t}^* + b_{\text{increase}} \cdot d_{\text{increase},t}^* + b_{\text{maintain}} \cdot d_{\text{maintain},t}^* + \epsilon_t \quad (7)$$

The optimization results are:

	estimate	std. error	t value	Pr(> t)
c	0.04699	0.03458	1.359	0.174
a_2	-0.04822	0.01287	-3.746	0.000 *
a_5	-0.05493	0.01288	-4.265	0.000 *
b_{cut}	-1.61216	0.40609	-3.970	0.000 *
b_{increase}	0.65529	0.23796	2.754	0.006 *
b_{maintain}	0.98332	0.40133	2.450	0.014 *

AIC: 28505.86

The optimal scenarios are:

$$\begin{aligned} \text{for } d_{\text{cut},t}: & \quad \text{sc.after} = (0, 2, 0.0) \\ \text{for } d_{\text{increase},t}: & \quad \text{sc.after} = (2, 5, 0.4) \\ \text{for } d_{\text{maintain},t}: & \quad \text{sc.after} = (1, 1, 0.0) \end{aligned}$$

The optimally modified dummy variables for this regression model are shown in Figure 3.

A comparison of estimation results (6) and (8) reveals that increase and maintain decisions have no significant impact on oil price return the very day they are made. However, modifying the pattern of impact results in a significant regressor. It is remarkable that all three optimal modifications point towards an aftereffect of OPEC decisions on the expected return. In particular, a cut (increase, maintain) decision is expected to reduce (raise, resp.) returns.

The regression model in **B** (equation (7)) leaves no significant autocorrelation pattern in the residual series. There is, however, significant autocorrelation in the series of squared residuals, which is indicative of heteroskedasticity, see Figure 4. The residual series from model **B** is therefore further analyzed on the basis of a GARCH process.

5.2 Augmenting the model with a GARCH process

The series (ϵ_t) in (7) is now modeled as a GARCH process. We shall present three fitted models: a GARCH without covariates, a GARCH with unmodified covariates, and a GARCH with optimally modified covariates.

⁴The asterisk * indicates significance at the 5% level.

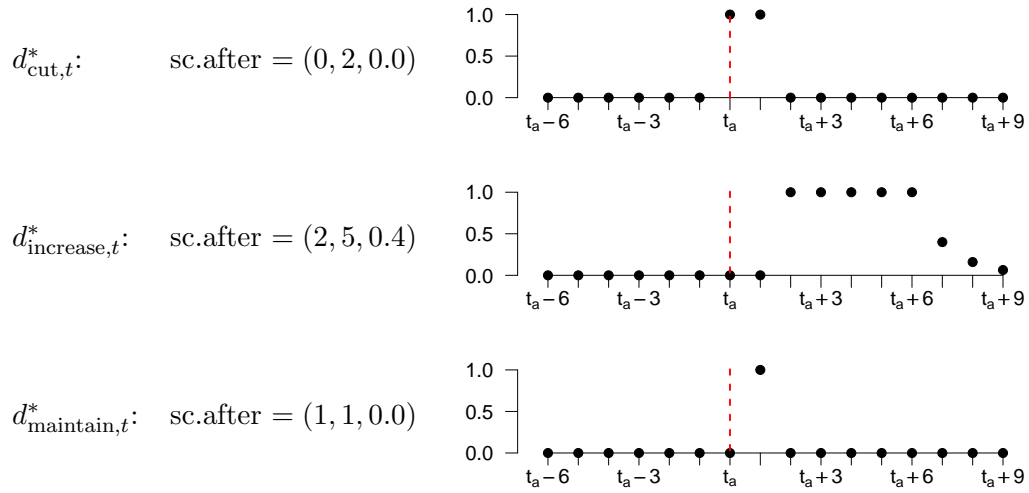


Figure 3: Optimally modified dummy variables in the regression model

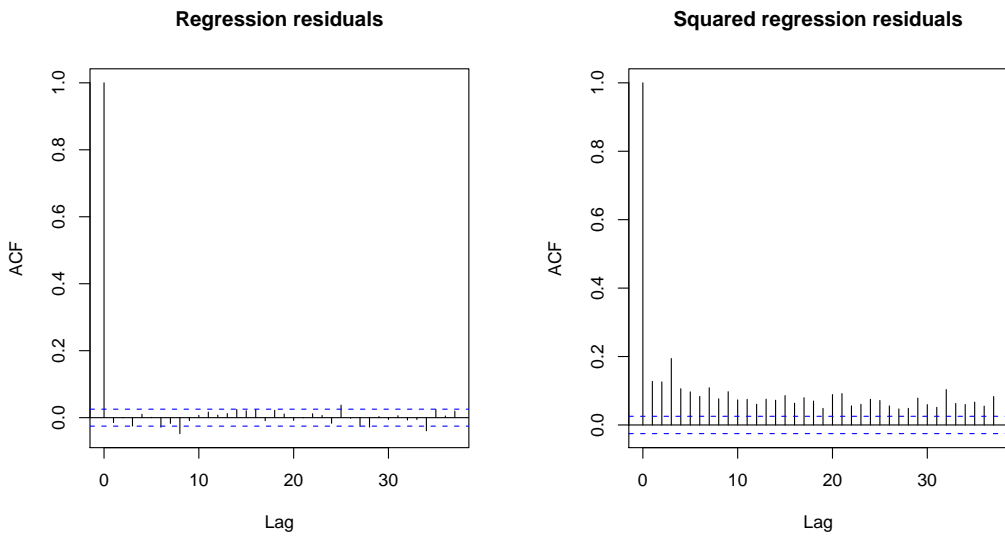


Figure 4: Correlograms of model (7) regression residuals and squared regression residuals

A. GARCH without dummy variables

This amounts to a GARCH(1,1) specification:

$$h_t = \alpha_0 + \alpha_1 \cdot \epsilon_{t-1}^2 + \beta \cdot h_{t-1} \quad (9)$$

Estimation results for this model are:

	estimate	std. error	t value	Pr(> t)	
α_0	0.06208	0.01338	4.63914	0.000	*
α_1	0.09325	0.00865	10.7854	0.000	*
β	0.90267	0.00863	104.541	0.000	*
AIC: 26732.49					

(10)

B. GARCH with unmodified dummy variables

Including the unmodified dummy variables in the conditional variance specification leads to:

$$h_t = \alpha_0 + \alpha_1 \cdot \epsilon_{t-1}^2 + \beta \cdot h_{t-1} + \gamma_{\text{cut}} \cdot d_{\text{cut},t} + \gamma_{\text{increase}} \cdot d_{\text{increase},t} + \gamma_{\text{maintain}} \cdot d_{\text{maintain},t} \quad (11)$$

Estimation results are:

	estimate	std. error	t value	Pr(> t)	
α_0	0.06774	0.01608	4.21235	0.000	*
α_1	0.10288	0.01028	10.0099	0.000	*
β	0.88918	0.01080	82.3495	0.000	*
γ_{cut}	5.70934	2.27010	2.51502	0.012	*
γ_{increase}	0.51702	0.49895	1.03620	0.300	
γ_{maintain}	1.16006	0.45374	2.55669	0.011	*
AIC: 26734.46					

(12)

OPEC decisions to cut or maintain production levels have a significant impact on volatility according to this model, but including the (unmodified) dummy variables has led to the undesirable effect of raising the AIC.

C. GARCH with optimally modified dummy variables

No modification of d_{increase} was found significant. The model is:

$$h_t = \alpha_0 + \alpha_1 \cdot \epsilon_{t-1}^2 + \beta \cdot h_{t-1} + \gamma_{\text{cut}} \cdot d_{\text{cut},t}^* + \gamma_{\text{maintain}} \cdot d_{\text{maintain},t}^* \quad (13)$$

with estimation results as follows:

	estimate	std. error	t value	Pr(> t)	
α_0	0.06074	0.01346	4.51307	0.000	*
α_1	0.09566	0.00885	10.8040	0.000	*
β	0.89849	0.00894	100.463	0.000	*
γ_{cut}	1.86783	0.84765	2.20354	0.028	*
γ_{maintain}	0.92651	0.41199	2.24888	0.025	*
AIC: 26723.39					

(14)

The optimal scenarios are:

$$\begin{aligned} \text{for } d_{\text{cut},t}: & \quad \text{sc.before} = (0, 1, 0.7) \\ \text{for } d_{\text{maintain},t}: & \quad \text{sc.before} = (-1, 3, 0.0) \end{aligned}$$

The optimally modified dummy variables for this GARCH model are shown in Figure 5. As is obvious from the plots, OPEC cut and maintain decisions are anticipated. Indeed, an aftereffect of announcements can be observed⁵, but this can be explained entirely in terms of pre-announcement effects.

⁵This is not shown here.

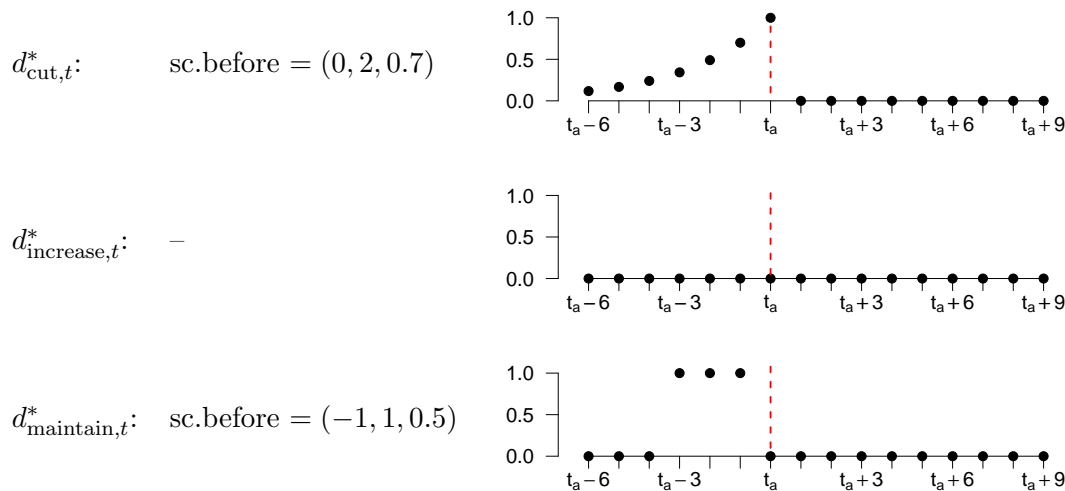


Figure 5: Optimally modified dummy variables in the GARCH model

6 Summary and Conclusions

The purpose of our investigation was to ascertain possible effects of OPEC announcements of decisions on the expectation and volatility behavior of WTI spot price changes in a daily time horizon. We apply a regression model with GARCH residuals, where three dummy variables indicating the day of the announcement of no change, increase, or cut of production level appear as exogenous variables in the regression as well as in the GARCH specification. A set of dummy variable modifications allow for modeling different patterns of anticipation or aftereffects of the cartel’s decision. The empirical basis of the study consisted of data from January 1986 through September 2009.

Our findings suggest that there is asymmetry in the behavior of daily WTI price changes: We found strong evidence that OPEC decisions are anticipated by market players, namely reflected in the volatility of price changes in the pre-announcement period, while aftereffects appear to play a significant role in the expectation of price changes. Moreover, the pattern of impact from OPEC announcements appears non-uniform with respect to the type of decision. Anticipation effects on volatility appear to be highly pronounced in the case of decisions to cut or maintain the production level, but are absent in the case of decisions to increase production. Aftereffects on expectation, on the other hand, were found significant in all three cases, and were further found to persist the longest in the case of decisions to increase the production level.

Our results reinforce the conception of the cartel’s meetings as a “channel through which the OPEC can induce volatility” (Fattouh [4]), in particular prior to the announcement. Finally, our results give rise to a hypothesis concerning the explanation of the behavior of volatility in the pre-announcement period, namely that information leakage is crucial in the creation of volatility.

Appendix: OPEC Announcements

Given are the dates of announcements and the number of days since the last announcement. For the decision, ○: quantity unchanged; +: quantity increased; -: quantity reduced.

date	weekday	diff.	price	dec.	date	weekday	diff.	price	dec.
1986-08-05	Tuesday		14.35	○	2001-06-05	Tuesday	54	27.84	○
1986-10-22	Wednesday	54	14.85	-	2001-07-03	Tuesday	20	26.28	○
1986-12-22	Monday	42	16.95	+	2001-07-25	Wednesday	15	26.71	-
1987-06-29	Monday	128	20.38	+	2001-09-27	Thursday	45	22.80	○
1987-12-14	Monday	119	17.47	-	2001-11-14	Wednesday	34	19.63	-
1988-06-14	Tuesday	128	16.85	○	2001-12-28	Friday	28	20.42	-
1988-11-28	Monday	118	14.93	+	2002-03-15	Friday	52	24.47	○
1989-06-07	Wednesday	134	19.70	+	2002-06-26	Wednesday	71	26.67	○
1989-09-28	Thursday	81	19.99	+	2002-09-19	Thursday	58	29.49	○
1989-11-28	Tuesday	43	19.33	+	2002-12-12	Thursday	58	28.20	+
1990-07-27	Friday	169	20.07	+	2003-01-13	Monday	20	32.08	+
1990-12-13	Thursday	99	26.45	○	2003-03-11	Tuesday	39	36.81	○
1991-03-12	Tuesday	61	20.06	-	2003-04-24	Thursday	31	27.52	+
1991-06-04	Tuesday	58	20.90	○	2003-06-11	Wednesday	33	32.17	○
1991-09-25	Wednesday	80	22.11	+	2003-07-31	Thursday	35	30.56	○
1991-11-27	Wednesday	45	21.38	-	2003-09-24	Wednesday	38	28.19	-
1992-02-17	Monday	56	19.42	-	2003-12-04	Thursday	49	31.24	○
1992-05-22	Friday	68	20.79	○	2004-02-10	Tuesday	43	34.03	-
1992-09-17	Thursday	83	22.23	+	2004-03-31	Wednesday	35	35.75	○
1992-11-27	Friday	50	20.29	+	2004-06-03	Thursday	44	39.29	+
1993-02-16	Tuesday	53	19.59	-	2004-09-15	Wednesday	71	43.83	+
1993-06-10	Thursday	79	19.27	○	2004-12-10	Friday	60	40.71	○
1993-09-29	Wednesday	77	18.73	+	2005-01-31	Monday	33	48.25	○
1993-11-24	Wednesday	40	15.73	○	2005-03-16	Wednesday	31	56.50	+
1994-03-28	Monday	84	14.15	○	2005-06-15	Wednesday	63	55.53	+
1994-06-16	Thursday	56	19.83	○	2005-10-10	Monday	81	60.71	○
1994-11-22	Tuesday	111	17.70	○	2005-12-12	Monday	43	61.36	○
1995-06-20	Tuesday	143	18.01	○	2006-01-31	Tuesday	33	67.86	○
1995-11-22	Wednesday	109	17.93	○	2006-03-08	Wednesday	25	60.06	○
1996-06-07	Friday	135	20.28	+	2006-06-01	Thursday	59	70.11	○
1996-11-29	Friday	122	23.70	○	2006-09-11	Monday	69	65.42	○
1997-06-26	Thursday	144	18.84	○	2006-10-20	Friday	29	57.35	-
1997-12-01	Monday	108	18.76	+	2006-12-14	Thursday	37	62.48	-
1998-03-30	Monday	81	16.32	-	2007-03-15	Thursday	61	57.52	○
1998-06-24	Wednesday	60	14.54	-	2007-09-11	Tuesday	124	78.16	+
1998-11-25	Wednesday	108	10.86	○	2007-12-05	Wednesday	60	87.45	○
1999-03-23	Tuesday	78	15.36	-	2008-02-01	Friday	39	89.03	○
1999-09-22	Wednesday	127	24.26	○	2008-03-05	Wednesday	22	104.45	○
2000-03-29	Wednesday	129	26.36	-	2008-09-10	Wednesday	131	102.66	+
2000-06-21	Wednesday	58	33.64	+	2008-10-24	Friday	32	63.34	-
2000-09-11	Monday	55	35.14	+	2008-12-17	Wednesday	54	40.17	-
2000-11-13	Monday	45	34.30	○	2009-03-15	Sunday	88	46.22	○
2001-01-17	Wednesday	43	29.77	-	2009-05-28	Thursday	64	65.09	○
2001-03-19	Monday	42	26.17	-	2009-09-10	Thursday	115	71.95	○

References

- [1] Bollerslev, T. (1986): Generalized autoregressive conditional heteroscedasticity. *Journal of Econometrics* 31, 307–327.
- [2] Deaves, R. & Krinsky, I. (1992): The behavior of oil futures returns around OPEC conferences. *Journal of Futures Markets* 12, 563–574.
- [3] Engle, R. (1982): Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica* 50, 987–1007.
- [4] Fattouh, B. (2005): The causes of crude oil price volatility. *Middle East Economic Survey* XLVIII, No. 13.
- [5] Fattouh, B. (2007): The drivers of oil prices: The usefulness and limitations of non-structural model, the demand-supply framework and informal approaches. Working Paper. Oxford Institute for Energy Studies, WPM 32, March 2007.
- [6] Horan, S.M., Peterson, J.H. & Mahar, J. (2004): Implied volatility of oil futures options surrounding OPEC meetings. *The Energy Journal* 25, 103–125.
- [7] Lin, S.X. & Tamvakis, M. (2006): The effects of OPEC conference announcements on oil prices. *The 26th USAEE/IAEE North American Conference*, Ann Arbor 2006.
- [8] Loderer, C. (1985): A test of the OPEC cartel hypothesis: 1974–1983. *The Journal of Finance* XL, 991–1006.
- [9] OPEC Secretariat (2003): OPEC production agreements: a detailed listing. *OPEC Review* 27, 65–77.
- [10] R Development Core team (2009): *R: A language and environment for statistical computing*. R foundation for statistical computing, Vienna, Austria. URL <http://www.R-project.org>.
- [11] Smith, J.L. (2005): Inscrutable OPEC? Behavioral tests of the cartel hypothesis. *The Energy Journal* 26, 51–82.
- [12] Wang, T., Wu, J. & Yang, J. (2008): Realized volatility and correlation in energy futures markets. *The Journal of Futures Markets* 28, 993–1011.
- [13] Wirl, F. & Kujundzic, A. (2004): The impact of OPEC Conference outcomes on world oil prices 1984–2001. *The Energy Journal* 25, 45–62.