

OTDK-dolgozat

2025

Budapesti Corvinus Egyetem

**OPEC BEJELENTÉSEK HATÁSA A KŐOLAJRA A GLOBÁLIS
BIZONYTALANSÁGOK IDEJÉN**

**OPEC ANNOUNCEMENTS AND UNCERTAINTY: WHEN DOES THE
OPEC MATTER?**

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Kézirat lezárása: 2025. január 15.

Acknowledgement

I would like to express my sincere gratitude to Milán Csaba Badics for being my consultant for almost two years in the Empirical Finance Research Program. He provided me with an opportunity to learn to analyze research papers, form a critical opinion, improve my academic writing, and acquire a deeper knowledge of econometrics and programming. He encouraged me to develop my own ideas and interest in the research of empirical finance. His help, guidance, and encouragement contributed greatly to the successful completion of this research.

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1 Introduction

Crude oil is the most traded commodity in the world. Its price fluctuations affect global economic activity and may even disrupt economic cycles, therefore it is widely investigated by academics and policymakers. The most influential market participant on the supply side is the Organisation of Petroleum Exporting Countries ¹, established to promote stability in the price of crude oil and subsuming exporting countries to jointly decide regarding the production of oil. The OPEC controls about 40% of the global crude oil supply and the member countries possess more than 80% of the proven oil reserves of the world ². Owing to its market power, the bi-annual production quota announcement of the cartel is widely investigated.

Event study literature analysed the impact of OPEC announcements on the crude oil market by calculating cumulative abnormal returns in an event window around the decision ³. The announcements are classified by the change in the production quota, in other words, they are grouped into cut, maintain, and increase decisions. Based on standard microeconomics the aforementioned changes in the level of production should raise, maintain and decrease crude oil prices respectively. Nevertheless, existing literature only confirmed the significant and positive post-announcement impact of cut decisions on crude oil returns (Demirer and Kutan, 2010; Loutia et al., 2016). To maintain decisions, oil prices mostly responded with a decrease (Lin and Tamvakis, 2010) and production quota increases had a negative or no effect (Li et al., 2022; Loutia et al., 2016).

Another field of academic research recently proposed risk and uncertainty indices that capture a particular component of uncertainty such as monetary policy, trading activity, or geopolitical risk among others. Empirical studies analysed crude oil prices in different uncertainty regimes. A positive shock to geopolitical risk increases instantaneously crude oil prices through the precautionary demand, which is an increased demand related to the future supply of oil (Bouoiyour et al., 2019). Uncertainty indices, such as economic policy uncertainty and monetary policy uncertainty, affect negatively the price of crude oil through global economic activity (Li et al., 2022).

Although in times of macroeconomic announcements uncertainty significantly affects the reaction of market participants to new information ⁴, in the case of OPEC decisions, the impact

¹Henceforth OPEC.

²For further information, see: https://www.opec.org/opec_web/en/data_graphs/330.htm

³The event windows are usually 5-10 days centered around the day of the production quota announcement (Demirer and Kutan, 2010; Loutia et al., 2016).

⁴The impact of uncertainty around economic announcements were confirmed by various studies. In the case

of uncertainty has never been investigated. Which uncertainty indices affect crude oil prices around OPEC decisions? How do they alter the response of crude oil to OPEC decisions? To answer these questions we analyse West Texas Intermediate futures returns in a 21 days event window around the scheduled OPEC announcements between 1985 and 2020.

My contribution to the literature on OPEC announcements is twofold. First, we analyse the joint impact of OPEC production quota announcements and the prevalent uncertainty environment. My research incorporates in the analysis most of the uncertainty indices that researchers found to have a significant impact on crude oil prices. Additionally, no research has included any explanatory variable in the event window around OPEC announcements. In the framework of cumulative abnormal returns, we propose to analyse the impact of OPEC announcements unlike previous studies; therefore further explanatory variables, such as global economic demand and the share of OPEC market share can be included.

Second, we incorporate geopolitical risk in the normal time return model of WTI futures to analyse the partial impact of OPEC production quota decisions. My findings indicate that the cartel responds to the prevalent geopolitical risk environment.

The remainder of the paper is organised as follows. In section 2 we summarise the literature related to OPEC announcements, crude oil, and uncertainty indices. In section 3 and 4 the description of the time-series and the methodology is presented. Section 5 details the empirical results and section 6 provides robustness tests. Section 7 concludes.

2 Literature Review

The first study examining the impact of OPEC quota decisions was written by Draper (1984) concluding that market participants' anticipation of the announcements leads to positive pre-announcement and negative post-meeting returns of heating oil futures. Deaves and Krinsky (1992) studied the response of the crude oil market and categorized OPEC decisions as good and bad news based on the sign of abnormal returns.

Recent studies classified OPEC announcements based on the decision type of production quota, analyzing the impact of cut, maintain, and increase decisions separately based on the of monetary policy target rate decisions De Pooter et al. (2021) found that monetary policy uncertainty hinders the pass-through of policy shocks to the longer-term bond yields. Increased policy uncertainty also weakens the reaction of crude oil futures and stock market indices to macroeconomic news. In the case of post-earning announcement, the magnitude of the drift is also influenced by market uncertainty inasmuch as the PEAD increases in a high VIX environment (Choi, 2019).

study of Guidi et al. (2006). The authors documented that quota cut decisions have a bigger impact than increase decisions. Furthermore, several studies confirmed that cut decisions lead to a positive and significant price drift in the crude oil market that lasts up to 20 days following the announcement (Demirer and Kutan, 2010; Schmidbauer and Rösch, 2012).

Nevertheless, in the existing literature, there is no consent regarding the impact of OPEC production quota maintain and increase announcements. For maintain decisions Ji and Guo (2015) found little evidence of positive post-announcement return drift while Demirer and Kutan (2010) documented a negative response of abnormal returns 20 days following the announcement. In a five days event window Loutia et al. (2016) found a significant and negative drift three days following the announcements that turned into positive returns afterward. Focusing on the conflicting results of maintain decisions Spencer and Bredin (2019) distinguished fail-to-agree and agreed-to-maintain decisions, concluding that the slope and curvature components of WTI crude oil futures prices responded differently to the two types of decisions ⁵.

Regarding the increase decisions Demirer and Kutan (2010) documented no return drift while Lin and Tamvakis (2010) found a significant decrease in crude oil prices. A possible explanation for the conflicting results was provided by Loutia et al. (2016) pointing out that the results are model dependent and in the case of EGARCH models with regressors, benchmark commodity indices yielded less significant results than their energy index counterparts.

To summarize, based on available research solely cut decisions seem to have the same, negative impact regardless of the abnormal return models. The production quota increase and maintain decisions lead to conflicting results. Table 1 provides a brief summary of the OPEC announcements literature, the implemented abnormal return model, and the main conclusions.

Recently, several indices have been published capturing only a particular component of uncertainty such as monetary policy uncertainty, trading uncertainty, macroeconomic uncertainty, or geopolitical risk. Existing literature explored the relationship between crude oil prices and these novel uncertainty components. Bouoiyour et al. (2019) documented that geopolitical risk ⁶ has a positive impact on the price of crude oil regardless of its price level. The authors also investigated the act and the threat components of geopolitical risk concluding that only the former has a significant effect. A possible explanation for these results is that non-OPEC members could adjust their production as the threat factor increases. The geopolitical risk was

⁵Spencer and Bredin (2019) decomposed the term structure of crude oil futures into the level, slope, and curvature factors.

⁶Henceforth GPR.

also found to increase the directional predictability from oil prices to the stock market returns of oil exporting countries (Kumar et al., 2021) and is also a good predictor of crude oil volatility (Liu et al., 2019).

Not only geopolitical conflicts but also macroeconomic fundamentals could influence the price of oil. For this reason, economic policy uncertainty and macroeconomic uncertainty influence significantly the price of crude oil. Analyzing the connectedness of US EPU and WTI returns Zhang and Yan (2020) documented a strong, negative correlation. Nonejad (2021) confirmed the negative impact of EPU on oil prices but concluded that in the case of oil price volatility, the relationship is positive. For macroeconomic uncertainty (Van Robays, 2012) found that increased oil price shocks have a larger impact in times of elevated macro uncertainty.

Author(s)	Sample period	Assets	Model	Conclusions
Draper (1984)	1961-1980	heating oil	market model	Significant pre-and post-announcement returns.
Deaves and Krinsky (1992)	1970 - 1990	NYMEX crude and heating oil futures	ARCH	Significant post-announcement heating and crude oil return following OPEC "good news".
Horan et al. (2004)	1989 - 2001	ATM options on generic first NYMEX crude oil	implied volatility of ATM options	Implied volatility increases prior to OPEC decisions and drop by 3-4% on the first day of the announcement.
Guidi et al. (2006)	1986 - 2004	OPEC Basket, Brent Crude and North Sea Crude spot return	mean return	OPEC quota cut decisions have a larger impact than increase decisions on US, UK stock return and oil prices..
Hyndman (2008)	1986 - 2002	WTI crude oil futures and spot return	market model	Significant and positive returns following quota cut and negative returns following quota maintain decisions.
Demirer and Kutan (2010)	1983 - 2008	NYMEX light sweet crude oil spot and futures	market model, Fama-French model, ARCH	OPEC quota cut announcements generate a significant post-announcement return.
Schmidbauer and Rösch (2012)	1986 - 2009	WTI spot return	GARCH with covariates	Significant post-announcement effect on oil price expectations that is positive for increase, maintain and negative for cut decisions.
Loutia et al. (2016)	1991 - 2015	WTI and Brent crude oil spot return	EGARCH	OPEC announcement effect is: i) more significant for quota maintain and cut decisions ii) is sensitive to the benchmark index.
Spencer and Bredin (2019)	1991 - 2017	WTI futures (2nd, 3rd, 4th, 5th, 6th generic)	AR-GARCH, ARMA-GARCH	Agree-to-maintain and fail-to-agree maintain announcements have different impact on WTI returns.

Table 1: Summary of the existing literature on OPEC announcements.

Although several studies confirmed the importance of uncertainty and risk components in explaining oil price fluctuations, to my best knowledge this is the first time their impact is analyzed around OPEC production quota announcements. Around the quota announcements, uncertainty indices could alter the perception of OPEC quota decisions; therefore, the reaction of crude oil prices might be different. Similar patterns were documented around the release of macroeconomic indicators Kurov and Stan (2018) and the announcements of the Federal Open Market Committee (De Pooter et al., 2021). In the case of FOMC decisions, increased level of market uncertainty leads to a larger price drift (Neuhierl and Weber, 2021) of stock

market returns even prior to the announcements. A possible explanation provided by Hu et al. (2022) was that investors receive compensation for the sharply increasing uncertainty prior to the decision and the magnitude of the post-announcement drift is influenced by the drop in the level of uncertainty. In the case of crude oil market Horan et al. (2004) documented a similar pattern: implied volatility increases as OPEC bi-annual meetings are approaching and volatility drops on the first day of the announcement.

Nevertheless, even around OPEC announcements, the price of crude oil is influenced by other variables. The most important factor determining the price fluctuation is the supply and demand factor (Hamilton, 2021). Identifying oil supply and demand shocks Clements et al. (2019) concluded that supply shocks explain around 60% variation of crude oil prices, but precautionary demand, which is the demand associated with the uncertainty about the future supply of oil, explains around 30%. Kilian (2009) classified precautionary demand as the component that is not explained by the supply and demand factors in monthly crude oil price variations and concluded that it has a 77% impact. Given that demand and precautionary demand shocks differ based on the identification assumption of each research, we proxy global crude oil demand with the World Industrial Production index of Baumeister et al. (2022). The index is widely used to predict oil price volatility (Lv and Wu, 2022) as well as a control variable in the analysis of oil price fluctuations (Lyu et al., 2021).

In order to analyze the impact of the explanatory variables outlined above, the methodology applied in the studies of OPEC announcements has to be extended. The existing literature analyzed the cumulative average abnormal returns for the three decision types (cut, maintain, increase) and applied t-statistics or GARCH-based statistics to test for the significance of returns in the announcement window (Demirer and Kutan, 2010; Loutia et al., 2016). Nevertheless, that framework does not permit the inclusion of additional explanatory variables or the analysis of OPEC decisions conditional on other events or periods. Therefore, we apply the cumulative abnormal returns - and not the average cumulative abnormal returns - in my analysis as a dependent variable in OLS regression. This approach has been applied in the cross-sectional event study methodology (Al-Sharkas and Hassan, 2010) and recently it was also implemented on time series in order to determine significant factors affecting abnormal returns around earning announcements (Gyamfi-Yeboah et al., 2012).

To summarize, extensive literature confirmed the significant impact of OPEC announcements on the price of crude oil. Recently, with the development of new uncertainty indices, a strong

connection between oil prices and uncertainty has been documented. My contribution to the existing literature is to analyse the conditional impact of OPEC announcements on the price of crude oil while controlling for significant factors affecting oil prices. To my best knowledge, this is the first time the effect of uncertainty on the price of crude oil during OPEC announcements is investigated.

3 Data

3.1 Futures contracts

In the analysis, we focus on the West Texas Intermediate crude oil futures for two reasons. First, existing literature documented that Brent crude oil is less responsive to OPEC announcements (Loutia et al., 2016; Schmidbauer and Rösch, 2012). Second, the WTI has longer available historical prices dating back to 1985, when the sample period begins.

	WTI returns (%)
<i>Panel A: basic descriptive statistics</i>	
Mean	1.8223
Median	0.1059
Min	-56.8589
Max	26.1723
Std. Dev	0.4120
Skewness	-1.5629
Kurtosis	41.4779
N. of observations	9052
<i>Panel B: statistical tests</i>	
Jarque-Bera test	652734***
ADF	-19.8***
KPSS	0.05190

Table 2: Summary statistics on WTI returns.

To sample daily returns on crude oil futures the prices of the WTI first- and second front-month contracts and their corresponding trading volume are required. In the case of commodity futures market participants typically use the front-month contract and as the date of expiry approaches traders roll over to the next nearest contract, introducing a cyclical effect in the trading volume, open interest, and the price of commodity futures (Bessembinder and Seguin, 1992; Holmes and Rougier, 2005).

The “roll yield” is the difference in the price of futures contracts on the rollover day

(Bessembinder, 2018) that could lead to spurious returns in the event window around OPEC decisions and possibly contaminate the models of normal time returns. Therefore, the rollover to the second-month contract happens as its trading volume exceeds the front-month contract's as implemented by (Indriawan et al., 2021) in analysing FOMC announcements. Furthermore, in section 6 a robustness test is presented with a rollover happening one week before the expiry of the generic first contract.

Summary statistics of the log returns are presented in table 2. The returns are not distributed normally, but returns are stationary based on the KPSS test, and the null hypothesis of a unit root is also rejected based on the ADF test.

3.2 OPEC announcements

The WTI returns are analysed in the sample period between January 1985 and December 2020⁷. During this period 13 cut, 44 maintain and 16 oil production quota increase decisions were announced in scheduled bi-annual meetings⁸. The decisions are available on the official webpage of the OPEC since 2000, prior to that we relied on the classification implemented by previous studies (Känzig, 2021). The three announcement types are transformed into dummy variables and only the quota cut and increase are included in the regression⁹.

3.3 Risk and uncertainty measures

To assess the impact of risk and uncertainty in times of the announcements, those indices are included that have a significant impact on the price of crude oil in normal times based on the recent, existing literature.

An intuitive choice is the Geopolitical Risk Index of Caldara and Iacoviello (2022)¹⁰ given that the North African and Middle-East region, where the majority of OPEC countries are present, has been characterized by adverse geopolitical events. The GPR has two sub-indices for geopolitical threat and act components both available on a daily frequency. Bouoiyour et al.

⁷Since 2021, the nature of OPEC announcements changed as the OPEC and OPEC+ meetings are not held separately. The frequency of the meetings also altered and instead of the bi-annual OPEC meetings the OPEC and non-OPEC countries gather almost on a monthly basis to assess the oil market conditions and make possible adjustments. For this reason, the methodology implemented in this study cannot be applied to the analysis of decisions following January 2021.

⁸The extraordinary OPEC meetings were excluded from the analysis. Existing literature suggests that in the case of other macroeconomic decisions pre-announcement returns exist if market participants receive a signal prior to the data release (Ai and Bansal, 2018).

⁹Please find a detailed description of each OPEC announcement in appendix A.

¹⁰Henceforth GPR.

(2019) applied both indices concluding that mostly act geopolitical risks increase oil prices. In the main analysis, we include the GPR but also test for the impact of both components.

Existing literature also found a significant and negative impact of the Economic Policy Uncertainty index proposed by Baker et al. (2016). The EPU affects crude oil prices through the demand channel as higher policy uncertainty could lower economic production. Monetary policy uncertainty is closely related to the EPU and it was shown to be a significant predictor (Li et al., 2022). In the analysis, we apply the monetary policy uncertainty index of Husted et al. (2020) ¹¹.

The existing literature also found a strong impact of macroeconomic uncertainty inasmuch as higher uncertainty increases the responsiveness of crude oil prices to oil shocks (Van Robays, 2012). The macroeconomic uncertainty is proxied by the index of Jurado et al. (2015) that is based on more than a hundred aggregate economic, financial, and sectoral indicators.

3.4 Control variables

In the analysis of OPEC announcements, we include explanatory variables accounting for the global demand factor of crude oil and the amount of OPEC production as a share of global crude oil supply.

Considering that in the event window, only OPEC decisions could alter the supply side of crude oil, the demand factor must also be present to test whether it changes the reaction of crude oil to the announcements. Demand shocks could be included as an explanatory variable, however; their importance and magnitude in explaining oil price fluctuations vary dramatically based on the assumption of identification (Clements et al., 2019; Kilian, 2009). Therefore, we include the World Industrial Production ¹² index of Baumeister et al. (2022) that has been applied in the analysis of oil return and to forecast volatility (Guo et al., 2022; Lyu et al., 2021). The index extends the OECD measure of monthly World Industrial Production by including six additional, non-OECD countries. The new index explains around 75% of the IMF World Economic Outlook estimate of global GDP and also 79% of global petroleum product consumption.

To proxy the magnitude of the supply shocks produced by the OPEC decision the OPEC market share is implemented which is the ratio of the OPEC crude oil supply and the global oil production. The data has been collected from the official webpage of OPEC and is only

¹¹ The market-based measures of monetary policy uncertainty reflect only a particular set of investors' opinions participating in the options markets moreover, it might be contaminated by time-varying risk aversion.

¹² Henceforth WIP.

available on a yearly frequency. In the existing literature, it has been implemented to explain variations in the price of oil and also to explain the behavior of the cartel members (Coleman, 2012; De Santis, 2003).

Appendix A presents a summary table on all the variables, their frequency, source and description.

4 Methodology

Event study methodology is widely applied in the literature of empirical finance to analyze the reaction of financial instruments to new information disclosure like earning announcements, target rate decisions, or macroeconomic indicators releases and projections (MacKinlay, 1997).

In the case of OPEC bi-annual quota decisions, existing literature relied on the event study methodology of modeling the abnormal return prior to the event window and analyzing the cumulative abnormal returns around the announcements (Ji and Guo, 2015; Lin and Tamvakis, 2010). The excess returns are defined as the difference between the ex-post return and the predicted normal returns in the event window:

$$AR_t = R_t^{ex-post} - E(R_t) \quad (1)$$

Normal time returns were estimated by the market model, factor models (Draper, 1984), ARCH (Deaves and Krinsky, 1992), GARCH (Bina and Vo, 2007) or EGARCH models (Loutia et al., 2016) and even by assuming constant mean returns (Ji and Guo, 2015). To decide between these models we conduct various tests to choose the most suitable model and present multiple alternatives in the robustness check. First, we estimate the general market model and then we test for heteroscedasticity of the error terms and the time-varying volatility that is a stylized fact of crude oil returns. The applied tests and their results are described in appendix B. Based on the conducted tests the normal performance is estimated with a market model that has GARCH(1,1) effect on the volatility:

$$\begin{aligned} R_t &= \alpha + \beta_m R_{m,t} + \epsilon_t \\ \epsilon_t &= v_t \sqrt{h_t} \\ h_t &= \gamma_0 + \gamma_1 \epsilon_{t-1}^2 + \delta h_{t-1} \end{aligned} \quad (2)$$

Assuming that $t = 0$ is the day of the quota announcement, the model is estimated in an event

window $t \in [-80, -10]$ days prior to the decision of OPEC ¹³. Demirer and Kutan (2010) also applied a 70 days window prior to OPEC decisions to model the normal time returns of crude oil. The estimate of the model for the abnormal returns in the event window:

$$AR_t = \epsilon_t \quad (3)$$

The event window starts 10 days prior to the scheduled OPEC decisions and continues 10 days afterward similarly to Lin and Tamvakis (2010) and Spencer and Bredin (2019). The abnormal returns are cumulated linearly in the event window:

$$CAR_t = \sum_{i=-10}^t AR_t \quad (4)$$

To estimate the impact of OPEC quota decisions the cumulative abnormal returns for each day are regressed on the explanatory variables as implemented by Gyamfi-Yeboah et al. (2012). The following OLS regression is estimated for each day in the event window:

$$CAR_t = \alpha + \sum_i \beta_i D_{i,t} + \gamma_t Uncertainty_t + \sum_i \delta_i D_{i,t} \times Uncertainty_t + \Omega_t X_t + \epsilon_t \quad (5)$$

where $D_{i,t}$ are the dummy variables for quota cut and increase decisions, $Uncertainty$ represents the risk and uncertainty indices described in section 3. The X_t vector includes control variables, namely the OPEC share of global crude oil production and the World Industrial Production index of Baumeister and Hamilton (2019).

5 Empirical results

5.1 OPEC announcements and geopolitical risk

In the empirical analysis only the impact of the geopolitical risk is presented and the empirical results of the uncertainty indices are reported in appendix C. Regarding the impact of geopolitical risk Bouoiyour et al. (2019) documented a positive relationship between the price of crude oil and geopolitical act risk in times of elevated geopolitical uncertainty. Gu et al. (2021) estimated

¹³In order to avoid overlapping the OPEC announcement event window and the period of normal performance estimation, two OPEC announcements were excluded from the analysis: The 107th OPEC Meeting on 1999.03.23 (cut decision) and the 136th OPEC Meeting on 2005.06.15. (increase decision).

the response of crude oil to geopolitical risk shocks concluding that it immediately increases oil prices which is followed by a sharp drop. These results were confirmed by Abdel-Latif and El-Gamal (2020).

Table 3. presents the result of estimating equation 5 to test the impact of OPEC production quota announcements conditional on geopolitical uncertainty ¹⁴.

	<i>Dependent variable: WTI cumulative abnormal returns</i>					
	[-10, -5]	[-10, -1]	[-10, 0]	[-10, 1]	[-10, 5]	[-10, 10]
<i>Constant</i>	0.334 (0.068)	7.937 (0.910)	10.576 (0.859)	3.521 (0.242)	4.317 (0.785)	20.746 (1.337)
<i>D_{Cut}</i>	3.676 (0.911)	-0.910 (-0.277)	2.143 (0.296)	3.669 (1.116)	2.794 (0.780)	11.987* (1.978)
<i>GPR</i>	-0.004 (-0.949)	-0.022*** (-7.056)	-0.026*** (-5.493)	-0.017** (-2.267)	-0.008** (-2.297)	-0.041*** (-5.157)
<i>D_{Increase}</i>	-0.493 (-0.171)	-0.153 (-0.047)	-0.721 (-0.166)	-2.917 (-0.697)	-1.836 (-0.595)	-6.561 (-1.019)
<i>D_{Cut} × GPR</i>	-0.029 (-0.844)	0.023 (0.784)	0.0005 (0.008)	-0.002 (-0.089)	-0.027 (-0.807)	-0.107 (-1.602)
<i>D_{Increase} × GPR</i>	0.015 (0.572)	0.026 (0.879)	0.035 (0.953)	0.078* (1.991)	0.028 (1.026)	0.150** (2.536)
<i>X_t</i>	-	-	-	-	-	-
Observations	71	71	71	71	71	71
R ²	0.139	0.233	0.211	0.135	0.249	0.256

Table 3: Cumulative abnormal returns around OPEC announcements.

Note. Reported coefficients denote the response of cumulative abnormal returns estimated with equation 5. Returns are linearly cumulated starting from 10 days prior to the announcements ($t = -10$) to $(-5, -1, 0, 1, 5, 10)$ days in column 1, 2, . . . 6 respectively. Day 0 denotes the day of the announcement. The explanatory variables are the OPEC quota increase and cut decision dummy variables $D_{Increase}$, D_{Cut} , and the geopolitical risk Index (Caldara and Iacoviello, 2022). Additional control variables denoted by X_t are the World Industrial Production index, (Baumeister et al., 2022), and the OPEC production share. The sample period starts in January 1985 and ends in December 2020. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The heteroscedasticity-consistent standard errors are calculated based on the method of White (1980). T-values are reported in parentheses.

To highlight the main research question, the coefficients of the control variables are omitted, and the response of cumulative abnormal returns is not presented for every day in the event window. The original table is presented in appendix D.1. The results illustrate that there is no pre-announcement drift of crude oil returns in accordance with existing literature (Ji and Guo, 2015; Loutia et al., 2016). Nevertheless, the post-announcement effect is altered by geopolitical risk.

¹⁴Noting anew that the mean return equation is estimated with the S&P GSCI benchmark index and in section 6 robustness tests are presented with an alternative benchmark model.

Compared to other research on OPEC announcements the effect of the quota cut decisions has no significant impact ¹⁵, not even conditional on the geopolitical risk. A possible explanation is that the OPEC decisions depend on the state of the crude oil market imbalances and are also based on political affairs (Barsky and Kilian, 2002). In the sample period, eight out of the twelve quota cut decisions were announced after 2016, which was a turning point in OPEC production policy. Since mid-2014 the cartel increased its oil supply to squeeze higher-cost competitors out of the crude oil market, such as U.S. shale oil producers (Behar and Ritz, 2017). Following the attempt, between 2016 and 2017 the OPEC announced several cut decisions in a sequence ¹⁶ that might have been expected by market participants; therefore, the decision did not lead to an immediate change in the crude oil returns. Existing literature also documented that as the price of crude oil is lower, the OPEC production cut has little impact Lin and Tamvakis (2010) ¹⁷.

The most influential factor is the geopolitical risk that even before the announcement decreases the price of crude oil by 2.2% on average, and by 4.1% in the total event window ¹⁸. A possible explanation could be that the immediate and long-term effects of geopolitical risk on oil returns are different. Analysing the impact of GPR in Global Vector Autoregressive model, Abdel-Latif and El-Gamal (2020) concluded that a positive shock to geopolitical risk increases oil prices. Indeed, a geopolitical event such as the Gulf war or the current Russia-Ukraine conflict leads to a disruption in production causing an immediate rise in the price of crude oil due to precautionary demand (Kilian, 2009). However, in the longer term demand for crude oil decreases and so do oil prices. These findings were confirmed by Zhang et al. (2022) concluding that the trend in geopolitical risk predicts negatively crude oil prices.

Another intuitive explanation is that OPEC accommodates the geopolitical environment in its decisions and announces to increase its supplies as a response to an instantaneous shock in geopolitical risk that increases precautionary demand regardless of the future expected production. The cartel may decide to cut or maintain its production quota, to balance prices in the crude oil market when the demand and precautionary demand for crude oil have already decreased. In other words, higher geopolitical risk could determine the quota decision type that produces a

¹⁵Existing literature confirmed the significant and positive effect of production quota cut announcements that is independent of the applied normal return model (Demirer and Kutun, 2010; Ji and Guo, 2015; Lin and Tamvakis, 2010).

¹⁶A summary on the OPEC announcement decisions is presented in appendix A.

¹⁷Lin and Tamvakis (2010) defined three price bands based on the historical price of crude oil and assessed the impact of OPEC announcements in the three price environments.

¹⁸The geopolitical risk index of Caldara and Iacoviello (2022) has a mean of 100.5 and a standard deviation of 59.87 for the total period where the index is defined.

decline in crude oil prices.

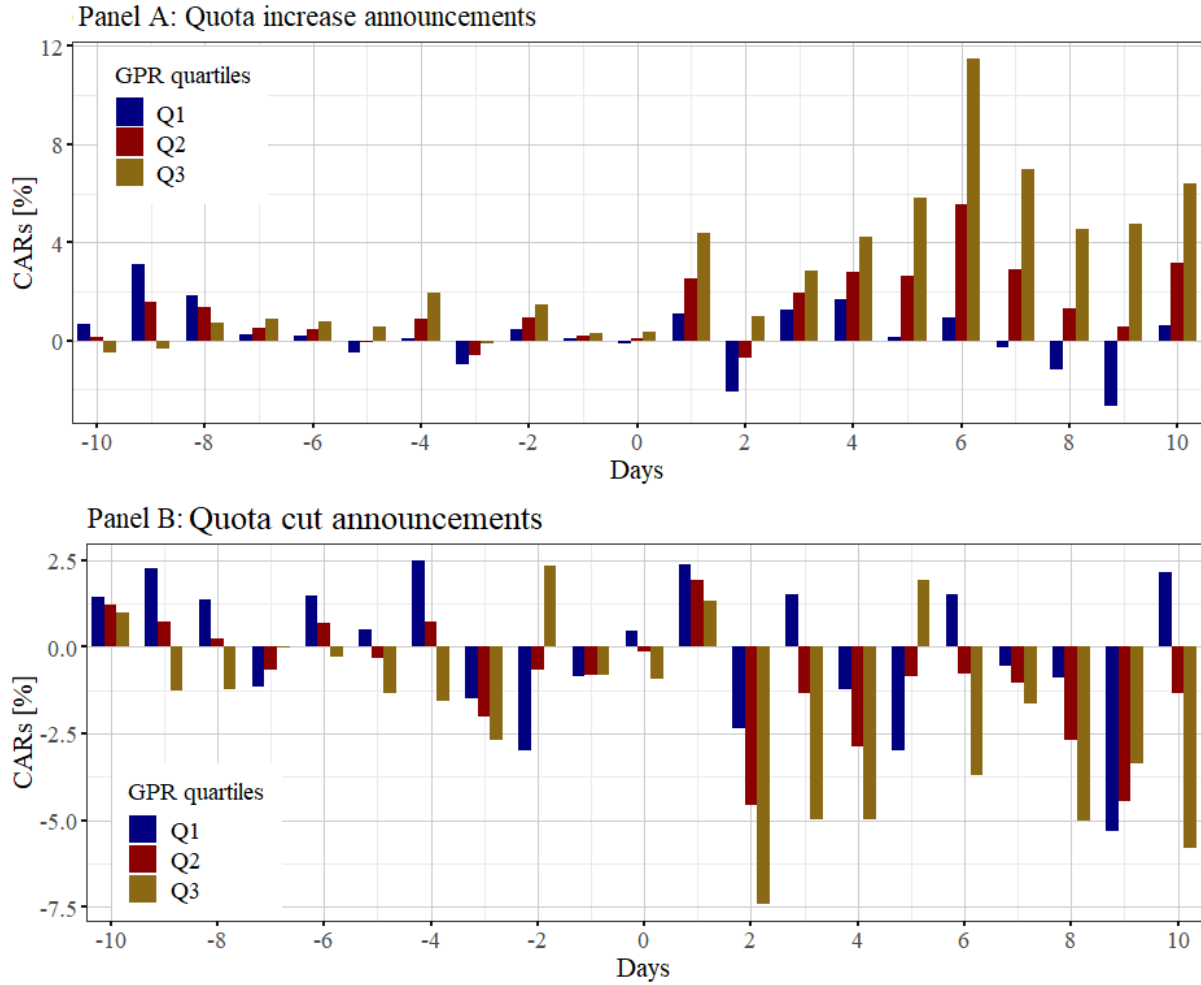


Figure 1: The joined impact of geopolitical risk and OPEC announcements on CARs

Note. The figure illustrates the average cumulative abnormal returns of WTI crude oil that corresponds to the joined impact of the geopolitical risk (Caldara and Iacoviello, 2022) and the production quota announcement. For each day in the event window, the three bars denote the sum of the coefficients of geopolitical risk, the announcement dummy, and their cross-product estimated by equation 5 and evaluated at the inner quartiles of the geopolitical risk index.

Indeed, Lin and Tamvakis (2010) confirmed that the production quota maintain decisions decrease significantly cumulative abnormal returns even before the announcement if and only if the prevalent price of crude oil is higher than average.

Considering the conditional impact of OPEC increase decisions, empirical results show that it has a significant and positive impact as the geopolitical risk increases. In appendix D.1 it is also presented that quota increase decisions have a significant and negative impact six days after the announcement. In other words, increase announcements lead to the desired, oil price decreasing impact in times of lower geopolitical risk.

Panel A of figure 1. illustrates the joined impact of production quota increase decisions and the geopolitical risk at the inner quartiles of GPR historical distribution ¹⁹. In the post-announcement period, the effect of the decision in the lower quartile is almost zero or slightly negative for those days when the increase decisions were significant ²⁰. In the middle and upper quartile of geopolitical risk, the increase decisions lead to a rise in the price of crude oil. Panel B illustrates the same, joined effect for OPEC crude oil supply quota cut decisions. Noting anew that cut decisions did not have any significant impact, the results seem to be noisy. Altogether, a cut decision mainly decreases oil prices as the GPR is in the middle and upper quartile.

5.1.1 Geopolitical act and threat risks

The following results present the same analysis conducted with the *act* and *threat* components of geopolitical risk. Caldara and Iacoviello (2022) constructed the geopolitical risk index with a dictionary-based method: searching newspapers regarding geopolitical events and counting the occurrence of the words specified in the dictionary. The act component only incorporates a subsample of words that are associated with war or terrorist attacks ²¹. The threat component includes words that are associated with military buildup and peace-, war-, nuclear-, and terrorist threats ²². Existing literature found that it is rather the act component that influences oil prices and the geopolitical threat only has a mild effect (Bouoiyour et al., 2019).

Table 4 illustrates the impact of geopolitical act and threat components. To simplify the analysis of the empirical results only the variables of interest are presented which are the increase dummy, the GPR component, and their cross-product. However, in appendix ?? and D.3 both regression tables are presented.

In the event window, the threat component has larger coefficients in other words, geopolitical threat decreases more crude oil returns than geopolitical act risk. However, its impact is not significant on all post-announcements days. Compared to the geopolitical threat index, the act component becomes statistically significant several days prior to the announcement, which could indicate that it influences oil prices regardless of the decisions as documented by existing

¹⁹The quartiles of the historical distribution are 65.9549, 89.4080, and 119.5466 respectively.

²⁰The joined cross-product of GPR and increase decisions became significant from day 5, as illustrated in appendix D.1.

²¹To exemplify, words in the war attack category are: military, troops, conflict, nuclear weapon etc. Words in the terrorist attack category are rebels, troops, ally, navy, army etc.

²²In the threat dictionary the following words are present: warn, fear, concern, sanction, embargo, declare, attack, strike etc.

literature (Bouoiyour et al., 2019; Coleman, 2012)²³.

	<i>Dependent variable: WTI cumulative abnormal returns</i>					
	[-10, -5]	[-10, -1]	[-10, 0]	[-10, 1]	[-10, 5]	[-10, 10]
<i>Panel A: Geopolitical act</i>						
$D_{Increase}$	0.269 (0.122)	-1.487 (-0.526)	0.215 (0.070)	-1.441 (-0.429)	-0.224 (-0.091)	-1.930 (-0.329)
GPR_{Act}	-0.001 (-1.278)	-0.013*** (-5.163)	-0.015*** (-5.656)	-0.016*** (-5.227)	-0.003*** (-2.836)	-0.023*** (-4.064)
$D_{Increase} \times GPR_{Act}$	0.008 (0.391)	0.046** (2.303)	0.029 (1.219)	0.063** (2.387)	0.012 (0.629)	0.106* (1.736)
<i>Panel B: Geopolitical threat</i>						
$D_{Increase}$	-1.278 (-0.361)	1.219 (0.512)	-1.814 (-0.364)	2.781 (0.525)	-4.082 (-1.294)	-5.715 (-1.056)
GPR_{Threat}	-0.019 (-0.724)	-0.031*** (-3.438)	-0.038** (-2.114)	-0.005 (-0.281)	-0.017 (-1.207)	-0.066*** (-3.127)
$D_{Increase} \times GPR_{Threat}$	0.021 (0.642)	0.005 (0.267)	0.042 (1.034)	0.016 (0.339)	0.051* (1.752)	0.138*** (3.022)

Table 4: Cumulative abnormal returns the effect of geopolitical act and threat indices.

Note. Reported coefficients denote the response of cumulative abnormal returns estimated with equation 5. Returns are linearly cumulated from 10 days prior to the announcements ($t = -10$) to $(-5, -1, 0, 1, 5, 10)$ days in column 1, 2, . . . 6 respectively. Day 0 denotes the day of the announcement. The explanatory variables are the OPEC quota increase and cut decision dummy variables, and the geopolitical risk act and threat index (Caldara and Iacoviello, 2022). Additional control variables are the World Industrial Production index, (Baumeister et al., 2022), and the OPEC production share. The table only reports the production quota increase, the geopolitical act and threat risk, and their cross-product. The sample period starts in January 1985 and ends in December 2020. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The heteroscedasticity-consistent standard errors are calculated based on the method of White (1980). T-values are reported in parentheses.

The cross-product of geopolitical risk components and the OPEC production quota decision dummy is significant in the case of geopolitical threat but insignificant for the geopolitical act. A possible explanation could be that the market participants are unable to assess the real effect of the threat component on the future price of oil. The OPEC could indicate with its production quota the willingness to intervene in the case of possible supply disruption. Meanwhile, with the increase of geopolitical act risk, OPEC and non-OPEC production must increase their production to ensure the balance in the crude oil market; therefore the quota decision could be expected by market participants.

²³Coleman (2012) analysed the fundamental measures that could explain oil price fluctuations and concluded that geopolitical events, such as wars in the Middle East and terrorist attacks significantly explain oil price movements. These components are only incorporated in the geopolitical act index.

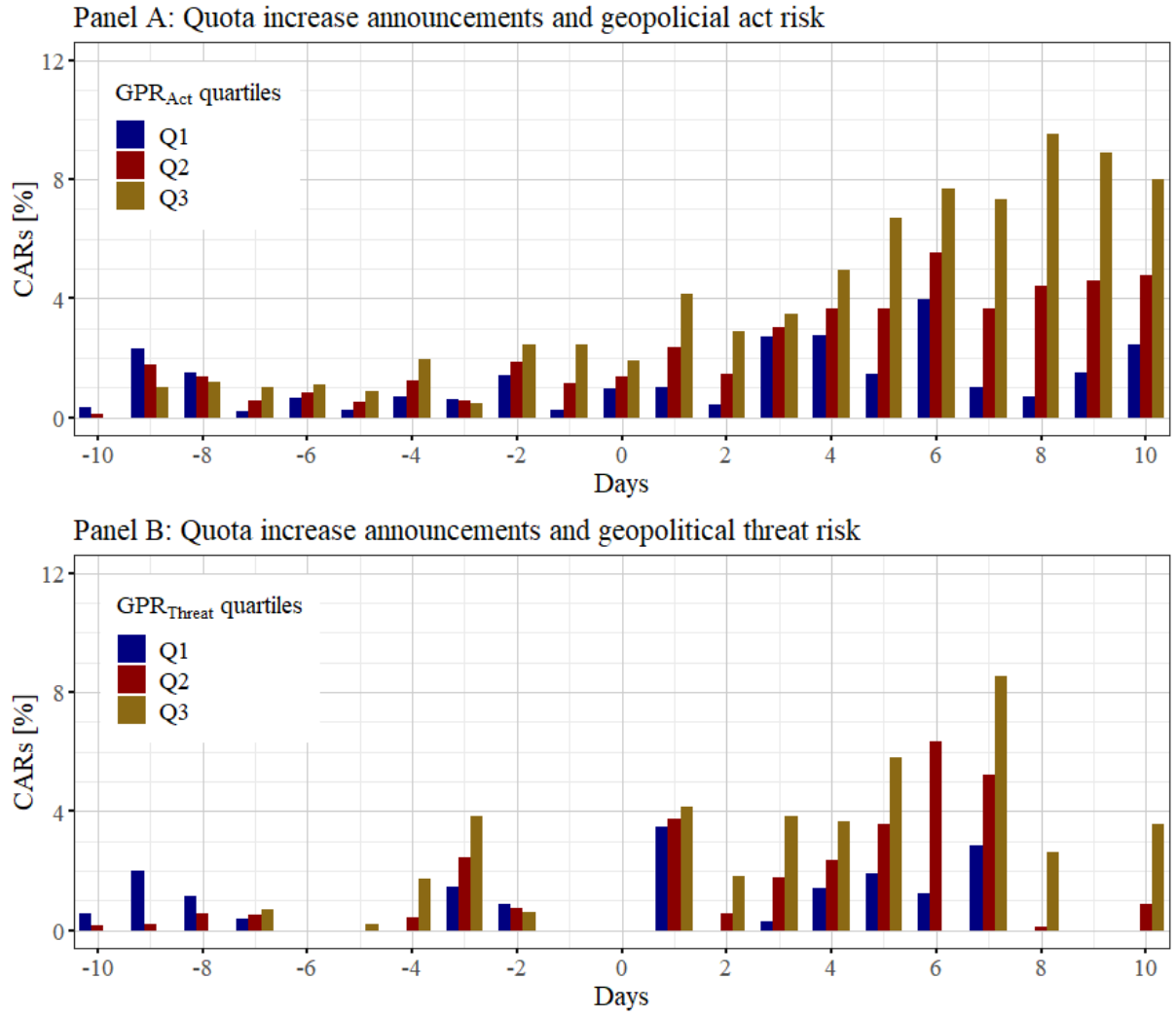


Figure 2: The joined impact of geopolitical risk act and threat components with OPEC announcements

Note. The figure illustrates the average cumulative abnormal returns of WTI crude oil that corresponds to the joined impact of the geopolitical act and threat risk (Caldara and Iacoviello, 2022) and the production increase quota announcement. For each day in the event window, the three bars denote the sum of the coefficients of the geopolitical act or threat risk, the announcement dummy, and their cross-product estimated by equation 5 and evaluated at the inner quartiles of the geopolitical risk index.

Figure 2. illustrates the joined impact of the geopolitical risk act and threat components with the OPEC increase announcements calculated as the sum of the $D_{Increase}$, $GPR_{Component}$ and $GPR_{Component} \times D_{Increase}$ coefficients.

Panel A illustrates that in times of higher geopolitical act risk cumulative abnormal returns increase even if OPEC decides to raise its production quota. In the case of higher threat risk, similarly to the act component oil returns increase in the post-announcement event window. Nevertheless, as the geopolitical threat risk is in the lower quartile of its historical distribution OPEC quota increase decision can lead to decreased oil prices.

To summarize, geopolitical act risk seems to have a significant effect even prior to the OPEC decisions and regardless of the quota change. These results are in align with the findings of Bouoiyour et al. (2019) indicating that geopolitical act has a more significant effect on crude oil prices. The cross-product of the threat component and the quota increase decision dummy has a significant impact, suggesting that OPEC indicates the severity of geopolitical threat risk with its quota decision.

5.2 Reconsidering the empirical framework

The empirical results suggest that geopolitical risk has a stronger impact on crude oil returns than the production quota decisions. Moreover, the geopolitical risk and its subcomponents explain cumulative abnormal return drift prior to the announcements. These conclusions led us to reconsider the empirical framework. In the previous sections, we have analysed whether the uncertainty environment alters the reaction of crude oil returns to OPEC decisions. In this section, we consider the reverse relationship and investigate whether the geopolitical risk environment drives OPEC decisions.

The applied event study methodology must meet the following requirements. First, the prediction of the expected returns must be precise. High price volatility and volatility clustering is a well-known feature of the crude oil market (Morana, 2001) and previous event study literature applied similar autoregressive conditional heteroskedasticity models with commodity index external regressors to predict crude oil returns (Demirer and Kutan, 2010; Loutia et al., 2016). Second, the markets must be weakly efficient. Third, the outcome of the event has to be unpredictable. We believe that the first two assumptions are fulfilled in our research; however, the third assumption may be violated if the OPEC production quota decisions respond to the geopolitical risk environment.

To test this hypothesis, in the empirical framework we rewrite the normal time return model and include the geopolitical risk index as an external regressor in the mean equation of the GARCH(1,1) model:

$$\begin{aligned}
 R_t &= \alpha + \beta_1 R_{m,t} + \beta_2 GPR_t + \epsilon_t \\
 \epsilon_t &= v_t \sqrt{h_t} \\
 h_t &= \gamma_0 + \gamma_1 \epsilon_{t-1}^2 + \delta h_{t-1}
 \end{aligned} \tag{6}$$

The specification leads us to the assumption that geopolitical risk affects crude oil returns regardless of the OPEC decisions as it was documented by existing literature (Gu et al., 2021).

This way the abnormal returns estimated with equation 1 only reflect the impact of the OPEC production quota announcements. Therefore the cumulative abnormal returns are only regressed on the two OPEC production quota decision dummies and the explanatory variables.

$$CAR_t = \alpha + \beta_1 D_{Increase} + \beta_2 D_{Cut} + \Omega_t X_t + \epsilon_t \quad (7)$$

The results, reported in table 5 indicate that the OPEC production quota decisions have no significant impact, in other words, they do not explain cumulative abnormal returns.

	<i>Dependent variable: WTI cumulative abnormal returns</i>					
	[-10, -5]	[-10, -1]	[-10, 0]	[-10, 1]	[-10, 5]	[-10, 10]
<i>Constant</i>	0.226 (0.111)	4.414 (1.253)	4.616 (0.985)	1.644 (0.362)	36.853 (1.015)	44.994 (1.027)
<i>D_{Cut}</i>	0.520 (0.523)	1.031 (0.681)	1.742 (0.984)	1.678 (0.943)	0.146 (0.035)	-1.572 (-0.311)
<i>D_{Increase}</i>	-0.138 (-0.167)	-0.014 (-0.012)	0.562 (0.489)	0.258 (0.211)	-1.998 (-0.559)	-6.438 (-1.310)
<i>X_t</i>	-	-	-	-	-	-
Observations	71	71	71	71	71	71
R ²	0.016	0.050	0.070	0.046	0.101	0.105

Table 5: Cumulative abnormal returns around OPEC announcements.

Note. Reported coefficients denote the response of cumulative abnormal returns estimated with equation 7. Returns are linearly cumulated from 10 days prior to the announcements ($t = -10$) to $(-5, -1, 0, 1, 5, 10)$ days in column 1, 2, . . . 6 respectively. Day 0 denotes the day of the announcement. The explanatory variables are the OPEC quota increase and cut decision dummy variables. Additional control variables are the World Industrial Production index, (Baumeister et al., 2022), and the OPEC production share. The table only reports the production quota increase and cut coefficients. The sample period starts in January 1985 and ends in December 2020. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The heteroscedasticity-consistent standard errors are calculated based on the method of White (1980). T-values are reported in parentheses.

These findings confirm that the assumption concerning the unpredictability of the OPEC production quota decisions does not hold. Presumably, the cartel reacts to the prevalent geopolitical risk environment and this is the reason why its announcement is not new information to the participants. The findings are in align with the significant impact of the geopolitical risk prior to the OPEC announcements.

6 Robustness check

This section presents alternative specifications of the implemented models and employed data to illustrate that the main empirical results do not depend on an arbitrary choice of an index, or method. Panel A of table 6, 7, 8 presents again the results of table 3 to facilitate comparison.

6.1 West Texas Intermediate futures contract rollover

The dependent variable, the cumulative abnormal returns are calculated from the West Texas Intermediate futures returns. As the futures contracts expire, the continuous time series of futures ²⁴ are constructed by rolling over to the next month's contract on the day of expiry. On the day of the futures contract expiry, a significant roll yield was documented for crude oil contracts (Bessembinder, 2018). The roll yield could lead to significant, and positive returns in the announcements window that was not caused by OPEC decisions. Therefore, the price of crude oil returns was constructed based on the first and second generic futures. The first rollover from the first generic futures happened on the day when the trading volume of the second generic futures exceeded that of the closest contract.

An alternative technique is to roll over to the second contract some days prior to the day of the futures contract expiry (Han et al., 2016). A new time-series of futures prices is constructed with the rollover happening seven days prior to the expiry of futures contracts similar to the study of Demirer and Kutan (2010) ²⁵.

Panel B of table 6 illustrates the response of cumulative abnormal returns estimated with the alternative rollover method.

The impact of the geopolitical risk index seems to be larger than in the baseline results and significant on all days. Its cross-product with the production quota increase decisions is positive and significant in the post-announcement period. In conclusion, the results are qualitatively unchanged.

²⁴For instance: generic first WTI crude oil futures prices are constructed by the front-month futures contracts.

²⁵The WTI futures contract expires 3 days prior to the 25th calendar day of the month. If that day is not a business day, then the contract expires on the third business day prior to the closest preceding business day of the 25th calendar day of the month. For further information visit the webpage of the U.S. Energy Information and Administration.

	<i>Dependent variable: WTI cumulative abnormal returns</i>					
	[-10, -5]	[-10, -1]	[-10, 0]	[-10, 1]	[-10, 5]	[-10, 10]
<i>Panel A: Baseline results</i>						
$D_{Increase}$	-0.493 (-0.171)	-0.153 (-0.047)	-0.721 (-0.166)	-2.917 (-0.697)	-1.836 (-0.595)	-6.561 (-1.019)
GPR	-0.004 (-0.949)	-0.022*** (-7.056)	-0.026*** (-5.493)	-0.017** (-2.267)	-0.008** (-2.297)	-0.041*** (-5.157)
$D_{Increase} \times GPR$	0.015 (0.572)	0.026 (0.879)	0.035 (0.953)	0.078* (1.991)	0.028 (1.026)	0.150** (2.536)
<i>Panel B: Rollover on date</i>						
$D_{Increase}$	-1.546 (-0.325)	-2.132 (-0.552)	-2.280 (-0.364)	-1.147 (-0.206)	-8.289 (-1.383)	-11.348 (-1.601)
GPR	-0.026*** (-5.121)	-0.022*** (-8.146)	-0.028*** (-5.020)	-0.017* (-1.998)	-0.025*** (-3.188)	-0.045*** (-4.575)
$D_{Increase} \times GPR$	0.032 (0.783)	0.064** (2.264)	0.054 (1.072)	0.065 (1.303)	0.148*** (3.668)	0.203*** (3.321)

Table 6: Robustness check with an alternative rollover of WTI futures contracts.

Note. Reported coefficients denote the response of cumulative abnormal returns estimated with equation 5. Returns are linearly cumulated from 10 days prior to the announcements ($t = -10$) to $(-5, -1, 0, 1, 5, 10)$ days in column 1, 2, $\dots$ 6 respectively. Day 0 denotes the day of the announcement. The main explanatory variables are the OPEC production quota increase decision dummy variables, and the geopolitical risk index (Caldara and Iacoviello, 2022). The sample period starts in January 1985 and ends in December 2020. *, **, and *** indicate statistical significance at 1%, 5% and 10% level respectively. The heteroscedasticity-consistent standard errors are calculated based on the method of White (1980). T-values are reported in parentheses.

6.2 Cumulative abnormal returns

Further robustness check regarding the response variable focuses on the estimation of normal time returns modeled by a GARCH(1,1) process including external regressors in the mean equation. Loutia et al. (2016) pointed out that the energy counterpart of benchmark indices yields a different impact of OPEC announcements²⁶. Therefore in the mean equation of normal time returns estimated by equation 2, the benchmark index is replaced with its energy counterpart.

Panel B of table 7 illustrates that the results are unchanged when the S&P GSCI index is replaced by the S&P GSCI Energy index in the mean equation. In accordance with the study of Loutia et al. (2016), the impact of the cross-product is more significant when the normal time returns are estimated with the S&P GSCI Energy index; however, the results are qualitatively similar. The GPR significantly decreases, and its cross-product with the quota increase decision

²⁶Loutia et al. (2016) applied an EGARCH model with the BCI and S&P GSCI benchmark indices and their energy counterparts. The energy counterparts of the two indices yielded qualitatively similar but more significant results in the post-announcement period.

dummy raises crude oil returns.

	<i>Dependent variable: WTI cumulative abnormal returns</i>					
	[-10, -5]	[-10, -1]	[-10, 0]	[-10, 1]	[-10, 5]	[-10, 10]
<i>Panel A: Baseline results</i>						
$D_{Increase}$	-0.493 (-0.171)	-0.153 (-0.047)	-0.721 (-0.166)	-2.917 (-0.697)	-1.836 (-0.595)	-6.561 (-1.019)
GPR	-0.004 (-0.949)	-0.022*** (-7.056)	-0.026*** (-5.493)	-0.017** (-2.267)	-0.008** (-2.297)	-0.041*** (-5.157)
$D_{Increase} \times GPR$	0.015 (0.572)	0.026 (0.879)	0.035 (0.953)	0.078* (1.991)	0.028 (1.026)	0.150** (2.536)
<i>Panel B: S&P GSCI Energy</i>						
$D_{Increase}$	-0.724 (-0.235)	-1.009 (-0.300)	-0.891 (-0.196)	-3.516 (-0.829)	-6.072 (-1.231)	-6.097 (-1.021)
GPR	-0.004 (-0.988)	-0.023*** (-7.166)	-0.026*** (-5.139)	-0.017** (-2.144)	-0.028*** (-4.692)	-0.039*** (-5.516)
$D_{Increase} \times GPR$	0.016 (0.600)	0.035 (1.214)	0.035 (0.951)	0.083** (2.135)	0.126*** (4.267)	0.142** (2.645)

Table 7: Robustness check with an alternative benchmark index in the GARCH(1,1) model.

Note. Reported coefficients denote the response of cumulative abnormal returns estimated with equation 5. Returns are linearly cumulated from 10 days prior to the announcements ($t = -10$) to $(-5, -1, 0, 1, 5, 10)$ days in column 1, 2, ... 6 respectively. Day 0 denotes the day of the announcement. The main explanatory variables are the OPEC production quota increase decision dummy variable, and the geopolitical risk index (Caldara and Iacoviello, 2022). The sample period starts in January 1985 and ends in December 2020. *, **, *** indicate statistical significance at 1%, 5% and 10% level respectively. The heteroscedasticity-consistent standard errors are calculated based on the method of White (1980). T-values are reported in parentheses.

6.3 Global crude oil demand

Previous studies on OPEC decisions have not included the global demand for crude oil as a control variable in the announcement window. Empirical results suggest that in accordance with standard microeconomics, as global demand for crude oil rises its return increases. To present that these results do not depend on an arbitrary choice of a global demand index, the response of cumulative abnormal returns are re-estimated with the Global Economic Condition Index of Baumeister et al. (2022)²⁷ that proxies economic activity and demand. The index incorporates 16 factors such as energy-related indicators, real economic activity, transportation, and commodity prices among others.

²⁷Henceforth GECON.

	<i>Dependent variable: WTI cumulative abnormal returns</i>					
	[-10, -5]	[-10, -1]	[-10, 0]	[-10, 1]	[-10, 5]	[-10, 10]
<i>Panel A: Baseline results</i>						
$D_{Increase}$	-0.493 (-0.171)	-0.153 (-0.047)	-0.721 (-0.166)	-2.917 (-0.697)	-1.836 (-0.595)	-6.561 (-1.019)
GPR	-0.004 (-0.949)	-0.022*** (-7.056)	-0.026*** (-5.493)	-0.017** (-2.267)	-0.008** (-2.297)	-0.041*** (-5.157)
$D_{Increase} \times GPR$	0.015 (0.572)	0.026 (0.879)	0.035 (0.953)	0.078* (1.991)	0.028 (1.026)	0.150** (2.536)
WIP	0.074** (2.502)	0.105*** (2.717)	0.111*** (3.136)	0.090* (1.920)	0.092 (1.589)	0.154** (2.423)
<i>Panel B: GECON</i>						
$D_{Increase}$	-1.950 (-0.361)	-0.170 (0.512)	-1.313 (-0.364)	-2.698 (0.525)	-8.479* (-1.294)	-8.180 (-1.056)
GPR	-0.019 (-0.660)	-0.031*** (-0.050)	-0.038** (-0.283)	-0.005 (-0.581)	-0.017 (-1.799)	-0.066*** (-1.237)
$D_{Increase} \times GPR$	0.026 (1.084)	0.022 (0.744)	0.036 (0.926)	0.071* (1.674)	0.146*** (4.978)	0.159** (2.514)
$GECON$	3.301** (2.007)	4.785* (1.877)	4.798* (1.972)	5.959** (2.091)	4.565 (1.275)	5.363 (1.432)

Table 8: Robustness check with an alternative control variable.

Note. Reported coefficients denote the response of cumulative abnormal returns estimated with equation 5. Returns are linearly cumulated from 10 days prior to the announcements ($t = -10$) to $(-5, -1, 0, 1, 5, 10)$ days in column 1, 2, . . . 6 respectively. Day 0 denotes the day of the announcement. The main explanatory variables are the OPEC production quota increase decision dummy variables, and the geopolitical risk index (Caldara and Iacoviello, 2022). Additional control variables are the World Industrial Production Index (Baumeister et al., 2022) and the Economic Condition Index (Baumeister et al., 2022). The sample period starts in January 1985 and ends in December 2020. *, **, *** and * indicate statistical significance at 1%, 5% and 10% level respectively. The heteroscedasticity-consistent standard errors are calculated based on the method of White (1980). T-values are reported in parentheses.

Panel B of table 8 presents the response of cumulative abnormal returns estimated with the GECON. Results suggest that the index has a weaker, less significant but qualitatively similar impact, namely increasing crude oil returns. Moreover, the impact of the geopolitical risk and quota increase announcement does not change by applying an alternative global demand proxy.

To summarize, table 6, 7, 8 illustrates that the empirical results presented in section 5 are robust to the change of control variables, benchmark index, and alternative rollover methods as well.

7 Conclusion

In our research, we analysed the impact of OPEC announcements on crude oil prices conditional on prevailing uncertainty and with the inclusion of control variables that capture the

global demand and the market power of the cartel. Existing literature on OPEC decisions did not analyse the effect of uncertainty indices on the price of crude oil around the announcement and nor did control for general demand factor in the crude oil market.

Our research provides a twofold contribution to the existing literature. Analysing several uncertainty indices that significantly affect crude oil returns we concluded that only the geopolitical risk index affects significantly crude oil returns around OPEC decisions. In align with existing literature we confirmed that the geopolitical act component has a stronger impact; however, the threat component also produces a similar, significant price increase when the production quota increases. Second, we reconsidered the model specification and concluded that presumably, the cartel responds with its production quota to the prevalent geopolitical risk environment. These findings explain the significant impact of the geopolitical risk index prior to the announcements and also the conflicting results of the OPEC production quota increase decisions.

The results are robust to the choice of the benchmark index in the market model, the applied control variables and the rollover of crude oil futures contracts.

An interesting avenue for future research is to analyse the effect of financialization and OPEC announcements. Since the beginning of financialization, new market participants, such as institutional investors, began to actively trade in the commodity market. These market participants might react differently to OPEC production quota decisions than the traditional, commercial market participants that initially sought to hedge their exposure to production or consumption in the futures market.

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A Data summary table

This subsection presents a descriptive table of the data included in the research, their frequency, source, and any additional details that may be relevant to understand the analysis.

A.1 OPEC announcements

Announcement date	Decision	Notes
7/25/1985	maintain	74 Meeting
12/9/1985	maintain	76 Meeting
8/5/1986	maintain	78 Meeting
12/20/1986	increase	80 Meeting
6/27/1987	increase	81 Meeting
12/14/1987	cut	82 Meeting
6/14/1988	maintain	83 Meeting
11/28/1988	increase	84 Meeting
6/7/1989	increase	85 Meeting
11/28/1989	increase	86 Meeting
7/27/1990	increase	87 Meeting
12/13/1990	maintain	88 Meeting
6/4/1991	maintain	89 Meeting
11/27/1991	cut	90 Meeting
5/22/1992	maintain	91 Meeting
11/27/1992	increase	92 Meeting
6/10/1993	maintain	93 Meeting
11/24/1993	maintain	95 Meeting
6/16/1994	maintain	96 Meeting
11/22/1994	maintain	97 Meeting
6/20/1995	maintain	98 Meeting
11/22/1995	maintain	99 Meeting
6/7/1996	increase	100 Meeting
11/28/1996	maintain	101 Meeting
6/26/1997	maintain	102 Meeting
12/1/1997	increase	103 Meeting
6/24/1998	cut	105 Meeting
11/26/1998	maintain	106 Meeting
3/23/1999	cut	107 Meeting
9/22/1999	maintain	108 Meeting
3/29/2000	increase	109 Meeting
9/11/2000	increase	111 Meeting
3/17/2001	cut	114 Meeting
9/27/2001	maintain	117 Meeting
3/15/2002	maintain	119 Meeting
9/19/2002	maintain	121 Meeting

Announcement date	Decision	Notes
3/11/2003	maintain	124 Meeting
9/24/2003	cut	127 Meeting
3/31/2004	maintain	130 Meeting
9/15/2004	increase	132 Meeting
3/16/2005	increase	135 Meeting
6/15/2005	increase	136 Meeting
9/20/2005	increase	137 Meeting
3/8/2006	maintain	140 Meeting
9/11/2006	maintain	142 Meeting
3/15/2007	maintain	144 Meeting
9/11/2007	increase	145 Meeting
3/5/2008	maintain	148 Meeting
9/10/2008	maintain	149 Meeting
3/15/2009	maintain	152 Meeting
9/10/2009	maintain	154 Meeting
3/17/2010	maintain	156 Meeting
10/14/2010	maintain	157 Meeting
6/8/2011	maintain	159 Meeting
12/14/2011	maintain	160 Meeting
6/14/2012	maintain	161 Meeting
12/12/2012	maintain	162 Meeting
5/31/2013	maintain	163 Meeting
12/4/2013	maintain	164 Meeting
6/11/2014	maintain	165 Meeting
11/27/2014	maintain	166 Meeting
6/5/2015	maintain	167 Meeting
12/4/2015	maintain	168 Meeting
6/2/2016	maintain	169 Meeting
11/30/2016	cut	171 Meeting
5/25/2017	cut	172 Meeting
11/30/2017	cut	173 Meeting
6/22/2018	increase	174 Meeting
12/6/2018	cut	175 Meeting
7/1/2019	maintain	176 Meeting
12/5/2019	cut	177 Meeting
6/6/2020	cut	179 Meeting
12/3/2020	cut	180 Meeting

A.2 Data summary table

Variable group	Name	Description	Frequency	Source	Notes
Oil prices	WTI futures	Tickers: CL1, CL2, 1st and 2nd generic, and their corresponding volume	Daily	Bloomberg	Rollover to second generic when its trading volume exceeds the volume of generic first futures contract
Benchmark	FF3 factors	size of firms, book-to-market values, and excess return on the market	Daily	Kenneth French's webpage	Kenneth French's webpage
	S&P GSCI	Ticker: SPGSCI	Daily	Bloomberg	Main benchmark index
	S&P GSCI	Ticker: SPGSEN, sub-index of the S&P	Daily	Bloomberg	Robustness check
	Energy	GSCI	Daily		
Uncertainty	GPR	Geopolitical Risk Index of Caldara and Iacoviello (2022)	Daily		Geopolitical Risk Index
	EPU	Economic Policy Uncertainty index of Baker et al. (2016)	Monthly	Steven J. Davis webpage Lucas	Steven J. Davis webpage
	MPU	Monetary Policy Uncertainty index of Husted et al. (2020)	Monthly	Francisco Husted webpage Sidney	Lucas Francisco Husted webpage
	U_{Macro}	Macroeconomic Uncertainty index of Jurado et al. (2015)	Monthly	Ludwigson webpage	Sidney Ludwigson webpage
Control variables	OPECShare	OPEC production as a share of global crude oil supply	Yearly	OPEC webpage	
	WIP	World Industrial Production index of Baumeister et al. (2022)	Monthly	Christaine Baumeister webpage Christaine Baumeister webpage	Christaine Baumeister webpage
	GECON	Global Economic Condition Index of Bauer et al. (2022)	Monthly	Baumeister webpage	Christaine Baumeister webpage

B Model selection

Addressing the concern of arbitrary model selection that could alter the abnormal returns in the event window, this section presents the statistical tests on which the choice of the normal return model depends.

In section 3 basic descriptive statistics are presented about the WTI return series. Table 2 confirms that the time series is stationary and the hypothesis of a unit root process can be rejected.

First, we test for autocorrelation in the squared returns (volatility) by applying the Ljung-Box test for lags: $p = 1, 2, 3, \dots, 7$. The test statistics is calculated as:

$$Q(m) = n(n+2) \sum_{i=1}^m \frac{\rho_k}{n-k} \quad (8)$$

with ρ_k being the autocorrelation at lag k . The sample length is denoted by n and the m is time lag. If

$$Q(m) > \chi_{1-\alpha, m}^2 \quad (9)$$

then the null hypothesis can be rejected.

Table B. shows the autocorrelation between the volatility of WTI returns is significant at all lags being tested.

Lags	ACF	p-value
1	0.203	$2.2e - 16$
2	0.145	$2.2e - 16$
3	0.205	$2.2e - 16$
4	0.197	$2.2e - 16$
5	0.093	$2.2e - 16$
6	0.139	$2.2e - 16$
7	0.196	$2.2e - 16$

Testing the ARCH effect in the time series the Engle's ARCH LM test is implemented:

$$y_t^2 = \alpha_0 + \alpha_1 y_{t-1}^2 + \alpha_2 y_{t-2}^2 + \dots \alpha_q y_{t-q}^2 + \epsilon_t \quad (10)$$

with the null hypothesis: $\alpha_0 = \alpha_1 = \dots = \alpha_q = 0$. Table B presents the results:

Lags	1	2	3	4
P-value	0.01678	0.03314	0.0001749	$8.535e - 10$

Based on the test, the null hypothesis of no ARCH effect in the time series can be rejected.

In the existing literature, the market model was estimated with CAPM, that is with standard residuals (Demirer and Kutan, 2010), with heteroscedastic and ARCH, GARCH or EGARCH residuals (Loutia et al., 2016). First, we estimate the market model:

$$y_t = \alpha + \beta_t R_{m,t} + \epsilon_t \quad (11)$$

applying the S&P GSCI as the benchmark index in the commodity market. Table B1 illustrates the results, confirming that the S&P GSCI is a good benchmark index for forecasting.

<i>Dependent variable: WTI returns</i>	
<i>Constant</i>	−0.0001 (−0.427)
<i>S& GSCI</i>	1.643*** (135.414)
Observations	9,052
R ²	0.670
<i>Note:</i> *p<0.1; **p<0.05; ***p<0.01	

Table B1: OLS regression summary table.

Having considered that in the WTI time series significant volatility clustering is confirmed, we illustrate the autocorrelation and partial autocorrelation of the squared residuals in figure B1. Both plots show that the first spikes are out, therefore the autoregressive components will not be sufficient to model the residuals.

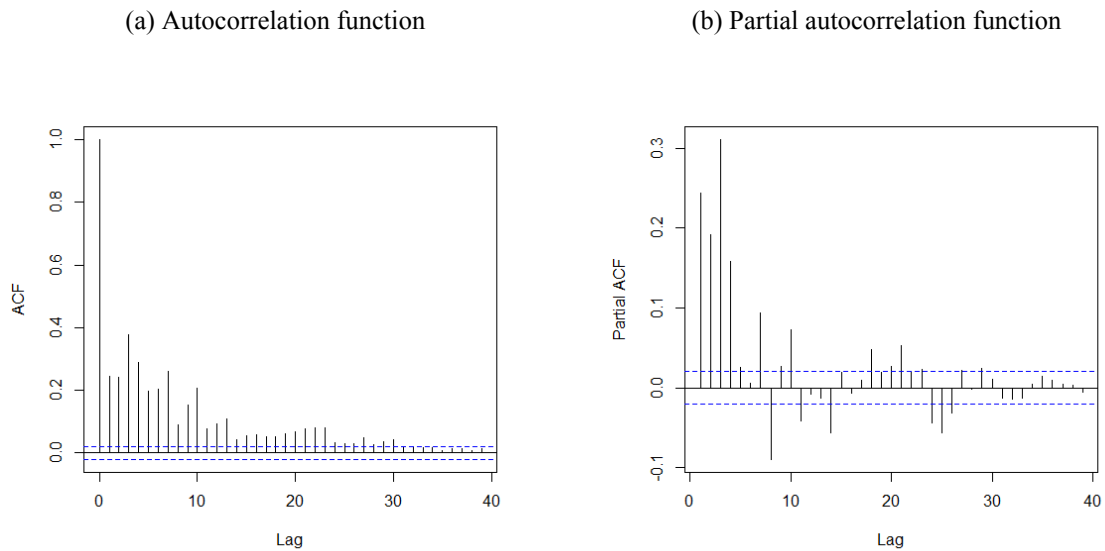


Figure B1: ACF and PACF of the squared residuals of the OLS regression 11

Estimating a GARCH(1,1) leaves no further the ARCH effect in the time series and based on the ARCH-LM tests. Therefore, this model is applied to estimate normal returns.

Lags	3	5	7
Statistic	0.5204	4.6896	6.3102
P-value	0.4707	0.1212	0.1217

C Uncertainty Indices

C.1 Macroeconomic uncertainty

To estimate the way macroeconomic uncertainty affects the impact of OPEC announcements on WTI returns, the uncertainty index of Jurado et al. (2015) is implemented.

	<i>Dependent variable: WTI cumulative abnormal returns</i>					
	[-10, -5]	[-10, -1]	[-10, 0]	[-10, 1]	[-10, 5]	[-10, 10]
<i>Constant</i>	8.588* (1.766)	20.958** (2.195)	20.995 (1.640)	15.220 (0.980)	17.582 (1.053)	29.148* (1.864)
<i>D_{Cut}</i>	-5.651 (-1.090)	-15.099** (-2.184)	-15.573** (-2.029)	-12.870 (-1.334)	-8.601 (-0.533)	-16.167 (-1.407)
<i>U_{Macro}</i>	-14.717*** (-2.660)	-25.627** (-2.445)	-21.110* (-1.938)	-22.252 (-1.664)	-21.765 (-1.312)	-23.155* (-1.980)
<i>D_{Increase}</i>	-7.856 (-0.519)	-36.570*** (-2.696)	-25.405 (-1.380)	-29.225 (-1.427)	-24.673 (-0.694)	-17.863 (-0.588)
<i>D_{Cut} × U_{Macro}</i>	10.386 (1.393)	26.887** (2.507)	27.945** (2.396)	25.562* (1.711)	16.737 (0.695)	29.150* (1.733)
<i>D_{Increase} × U_{Macro}</i>	14.333 (0.571)	63.814*** (2.814)	46.242 (1.525)	54.117 (1.602)	52.053 (0.917)	40.598 (0.818)
<i>X_t</i>	-	-	-	-	-	-
Observations	71	71	71	71	71	71
R ²	0.181	0.219	0.176	0.135	0.106	0.150

Table C2: Cumulative abnormal returns and macroeconomic uncertainty.

Note. Reported coefficients denote the response of cumulative abnormal returns estimated with equation 5. Returns are linearly cumulated from 10 days prior to the announcements ($t = -10$) to $(-5, -1, 0, 1, 5, 10)$ days in column 1, 2, ..., 6 respectively. Day 0 denotes the day of the announcement. The explanatory variables are the OPEC quota increase and cut decision dummy variables $D_{Increase}$, D_{Cut} , and the Macroeconomic Uncertainty Index (Jurado et al., 2015). Additional control variables denoted by X_t are the World Industrial Production index, (Baumeister et al., 2022), and the OPEC production share. The sample period starts in January 1985 and ends in December 2020. ***, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The heteroscedasticity-consistent standard errors are calculated based on the method of White (1980). T-values are reported in parentheses.

Existing literature has not analysed the direct effect of this particular index on crude oil return, but it was confirmed that other proxies of macroeconomic uncertainty increase oil price volatility (Van Robays, 2016). Furthermore, in times of elevated macro uncertainty oil returns are more responsive to oil price shocks (Van Robays, 2012), therefore the post-announcement cumulative abnormal returns might be more sensitive to changes in the production quota.

Table C2. illustrates the impact of macroeconomic uncertainty estimated with equation 5. In the pre-announcement event window, macroeconomic uncertainty decreases WTI returns; however, in the post-announcement window, the macroeconomic uncertainty and its joined impact with the decision dummies have no impact at 5% significance level. As opposed to previous research, around OPEC decisions macroeconomic uncertainty has little role in explaining oil price fluctuations.

C.2 Policy uncertainty indices

This subsection presents the analysis with the inclusion of economic policy uncertainty (Baker et al., 2016) and macroeconomic uncertainty (Husted et al., 2020) respectively ²⁸. The economic policy uncertainty is negatively correlated with the price of crude oil (Zhang and Yan, 2020) and a positive EPU shock leads to a larger oil price increase than geopolitical risk shocks (Gu et al., 2021). Furthermore, economic policy uncertainty indices also improve forecasts of oil price volatility (Wei et al., 2017). Nevertheless, the index had no impact on crude oil returns around OPEC decisions as illustrated by table C3.

Similarly to economic policy uncertainty, monetary policy uncertainty was shown to be a significant predictor of crude oil volatility (Li et al., 2022). However, as in the case of the economic policy uncertainty index, it has no pre- and post-announcement effect on crude oil prices in the event window.

In conclusion, uncertainty indices regarding the economic and monetary policy do not affect the price of crude oil around OPEC decisions. Possible explanations could be that both indices are available on a monthly frequency, as opposed to the geopolitical uncertainty index. Furthermore, as both indices have been recently published, only some studies have analysed its impact, mostly in networks, VAR models that are distinct from the models of event study analysis.

²⁸As opposed to the econometrics-based macroeconomics uncertainty of Jurado et al. (2015) these two indices are news-based, estimated by counting the occurrence of keywords in newspapers regarding economic policy.

	<i>Dependent variable: WTI cumulative abnormal returns</i>					
	<i>[-10, -5]</i>	<i>[-10, -1]</i>	<i>[-10, 0]</i>	<i>[-10, 1]</i>	<i>[-10, 5]</i>	<i>[-10, 10]</i>
<i>Panel A: Economic policy</i>						
$D_{Increase}$	1.176 (0.235)	2.668 (0.391)	6.091 (0.687)	5.078 (0.539)	-9.630 (-0.904)	-11.843 (-1.197)
EPU	-0.011 (-1.066)	-0.036 (-1.383)	-0.030 (-1.148)	-0.026 (-0.952)	-0.045 (-1.370)	-0.039 (-1.186)
$D_{Increase} \times GPR_{EPU}$	-0.005 (-0.097)	-0.006 (-0.099)	-0.037 (-0.456)	-0.015 (-0.172)	0.172 (1.666)	0.189* (1.952)
<i>Panel B: Monetary policy</i>						
$D_{Increase}$	5.789* (1.810)	8.622** (2.608)	10.065** (2.281)	12.141** (2.630)	6.893 (1.076)	2.171 (0.303)
MPU	0.010 (1.250)	0.006 (0.457)	0.003 (0.177)	0.005 (0.349)	-0.005 (-0.228)	-0.007 (-0.277)
$D_{Increase} \times MPU$	-0.050* (-1.675)	-0.056* (-1.888)	-0.066* (-1.836)	-0.076* (-1.951)	0.009 (0.136)	0.058 (0.747)

Table C3: Cumulative abnormal returns around OPEC announcements

Note. Reported coefficients denote the response of cumulative abnormal returns estimated with equation 5. Returns are linearly cumulated from 10 days prior to the announcements ($t = -10$) to $(-5, -1, 0, 1, 5, 10)$ days in column 1, 2, . . . 6 respectively. Day 0 denotes the day of the announcement. The explanatory variables are the OPEC quota increase and cut decision dummy variables, and the geopolitical risk index (Caldara and Iacoviello, 2022). Additional control variables are the World Industrial Production index, (Baumeister et al., 2022), and the OPEC production share. The table only reports the production quota increase, the geopolitical risk, and their cross-product. The sample period starts in January 1985 and ends in December 2020. * * *, ** and * indicate statistical significance at 1%, 5% and 10% level respectively. The heteroscedasticity-consistent standard errors are calculated based on the method of White (1980). T-values are reported in parentheses.

D OPEC announcements impact in daily frequency

D.1 Geopolitical risk

<i>Dependent variable: cumulative abnormal returns</i>										
	[-10, -10]	[-10, -9]	[-10, -8]	[-10, -7]	[-10, -6]	[-10, -5]	[-10, -4]	[-10, -3]	[-10, -2]	[-10, -1]
<i>Constant</i>	-3.882 (-1.244)	-7.269 (-1.547)	-2.657 (-0.565)	1.541 (0.270)	0.334 (0.068)	4.317 (0.785)	3.243 (0.490)	2.774 (0.400)	4.449 (0.632)	7.937 (0.910)
<i>D_{Cut}</i>	1.977 (0.948)	6.644*** (3.130)	4.546** (2.012)	-2.559 (-0.643)	3.676 (0.911)	2.794 (0.780)	7.443** (2.275)	0.013 (0.004)	-9.583** (-2.450)	-0.910 (-0.277)
<i>GPR</i>	0.003 (0.424)	0.007* (1.676)	0.004 (0.430)	0.001 (0.371)	-0.004 (-0.949)	-0.008** (-2.297)	-0.008** (-2.307)	-0.032* (-1.731)	-0.021*** (-4.790)	-0.022*** (-7.056)
<i>D_{Increase}</i>	2.182 (1.411)	7.397*** (2.866)	3.276 (1.455)	-0.539 (-0.193)	-0.493 (-0.171)	-1.836 (-0.595)	-2.253 (-0.822)	-2.068 (-0.544)	-0.786 (-0.155)	-0.153 (-0.047)
<i>OPECShare</i>	0.056 (0.679)	0.115 (0.848)	-0.022 (-0.166)	-0.214 (-1.057)	-0.185 (-1.212)	-0.334* (-1.926)	-0.258 (-1.319)	-0.225 (-1.052)	-0.276 (-1.236)	-0.417 (-1.654)
<i>WIP</i>	0.014 (1.358)	0.020 (0.904)	0.034 (1.577)	0.072* (1.983)	0.074** (2.502)	0.099*** (3.105)	0.076** (2.549)	0.087** (2.229)	0.076* (1.883)	0.105*** (2.717)
<i>D_{Cut} × GPR</i>	-0.011 (-0.662)	-0.073*** (-3.280)	-0.052* (-1.956)	0.020 (0.485)	-0.029 (-0.844)	-0.027 (-0.807)	-0.067** (-2.117)	0.010 (0.235)	0.120*** (2.826)	0.023 (0.784)
<i>D_{Increase} × GPR</i>	-0.025 (-1.485)	-0.072** (-2.196)	-0.026 (-1.015)	0.011 (0.479)	0.015 (0.572)	0.028 (1.026)	0.044* (1.960)	0.049 (1.387)	0.040 (0.808)	0.026 (0.879)

Dependent variable: Cumulative abnormal returns											
	[-10, 0]	[-10, 1]	[-10, 2]	[-10,3]	[-10, 4]	[-10, 5]	[-10, 6]	[-10, 7]	[-10, 8]	[-10, 9]	[-10, 10]
<i>Constant</i>	10.576 (0.859)	3.521 (0.242)	11.336 (0.757)	9.661 (0.687)	3.682 (0.240)	6.576 (0.400)	5.430 (0.321)	12.347 (0.725)	15.920 (0.917)	17.066 (1.134)	20.746 (1.337)
<i>D_{Cut}</i>	2.143 (0.296)	3.669 (1.116)	3.918 (0.796)	9.541** (2.045)	3.411 (0.425)	-9.041 (-0.926)	7.917 (1.015)	0.790 (0.165)	4.217 (0.750)	-7.747 (-0.951)	11.987* (1.978)
<i>GPR</i>	-0.026*** (-5.493)	-0.017** (-2.267)	-0.051*** (-3.665)	-0.030*** (-4.782)	-0.031*** (-5.951)	-0.029*** (-4.922)	-0.027*** (-2.946)	-0.040** (-2.427)	-0.043*** (-5.101)	-0.058*** (-3.599)	-0.041*** (-5.157)
<i>D_{Increase}</i>	-0.721 (-0.166)	-2.917 (-0.697)	-5.882 (-1.058)	-0.724 (-0.123)	-1.503 (-0.232)	-6.771 (-1.448)	-12.073*** (-2.171)	-9.235** (-2.075)	-8.220* (-1.938)	-11.744** (-2.393)	-6.561 (-1.019)
<i>OPECShare</i>	-0.486 (-1.491)	-0.303 (-0.753)	-0.463 (-1.160)	-0.516 (-1.328)	-0.312 (-0.733)	-0.354 (-0.768)	-0.330 (-0.695)	-0.581 (-1.201)	-0.697 (-1.452)	-0.655 (-1.528)	-0.858* (-1.904)
<i>WIP</i>	0.111*** (3.136)	0.090* (1.920)	0.109** (2.395)	0.129*** (2.768)	0.110** (2.232)	0.092 (1.589)	0.093 (1.553)	0.130** (2.037)	0.151** (2.500)	0.135** (2.129)	0.154** (2.423)
<i>D_{Cut} × GPR</i>	0.0005 (0.008)	-0.002 (-0.089)	-0.044 (-0.727)	-0.092* (-1.748)	-0.039 (-0.503)	0.121 (1.055)	-0.070 (-0.852)	0.020 (0.633)	-0.035 (-0.878)	0.095 (1.191)	-0.107 (-1.602)
<i>D_{Increase} × GPR</i>	0.035 (0.953)	0.078* (1.991)	0.108** (2.441)	0.060 (1.119)	0.079 (1.293)	0.134*** (4.861)	0.224*** (3.342)	0.176*** (6.033)	0.149*** (7.407)	0.196*** (6.290)	0.150*** (2.536)

Note:

*p<0.1; **p<0.05; ***p<0.01