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THE ECONOMIC IMPACT OF UNCERTAINTY ABOUT U.S. REGULATIONS OF THE ENERGY SECTOR

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ABSTRACT

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The Economic Impact of Uncertainty about U.S. Regulations of the Energy Sector [*]

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Abstract

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Keywords: uncertainty, regulatory policy, energy sector, economic activity, textual analysis, structural VAR

JEL Codes: C55, C82, E23, Q40

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1 Introduction

The energy sector, which mainly consists of oil and gas operations, plays an important role in fueling U.S. economic activities. It is identified as a critical sector because it provides an "enabling function" for other economic sectors.[1] Government energy-related policies thus can have substantial economic and social influence.

U.S. regulations of oil and gas operations have existed for over a century in various forms. In principal, these regulations can address market failures by eliminating adverse externalities on the environment, improve efficiency of resource allocation and reduce resource waste, and promote economic and social benefits, such as health and safety of the public. On the other hand, poorly designed or executed regulations may impose excess burden on energy companies, which can potentially yield negative effects on the aggregate economy. The economic role of energy regulatory policies is therefore an important issue, especially for jurisdictions with extensive oil and gas operations, such as Texas and New Mexico.[2]

Most existing research studies the effects of regulations on the energy sector (or the environment) from the perspective of benefits and/or costs of regulatory policies, such as Fabrizio et al. (2007), Davis and Wolfram (2012), Abito (2019), and Cicala (2022), among others. However, as demonstrated in an increasingly popular strand of literature (e.g., Bloom (2009), Baker et al. (2016), and Sinclair and Xie (2021), etc.), subjective perceptions of market participants, such as uncertainty about regulatory policies, could also affect their operational decisions. The notion applies to companies in the energy sector, as shown by the Federal Reserve Bank of Dallas Energy Survey of about 200 oil and gas firms that operate nationally and internationally. In a recent report of the survey (questions answered in the second quarter of 2022), almost one-third of the surveyed executives note that uncertainty about

[1] Presidential Policy Directive—Critical Infrastructure Security and Resilience: https://obamawhitehouse.archives.gov/the-press-office/2013/02/12/presidential-policy-directive-critical-infrastructure-security-and-resil.

[2] According to U.S. Energy Information Administration, crude oil is produced in 32 U.S. states and in U.S. coastal waters. In 2022, about 72 percent of total U.S. crude oil production came from five states: Texas, New Mexico, North Dakota, Colorado, and Alaska.

government regulations plays an important role in driving uncertainty regarding their firms' outlook.[3] In this paper, we construct measures of uncertainty about U.S. regulations of the energy sector and examine how they influence oil and gas companies' activities and aggregate economic outcomes. As far as we know, this paper is the first attempt to quantify the economic effects of uncertainty specifically about U.S. regulations of oil and gas industries.

Specifically, we first conduct a computational textual analysis to identify more than 600,000 news articles related to oil and gas exploration, production, and refining (together referred to as "oil and gas production" hereafter) that were published in hundreds of U.S. newspapers from January 1985 to December 2021. Using advanced natural language processing (NLP) techniques, we further refine the corpus to cover approximately 126,000 articles that contain news content discussing regulatory issues in the context of oil and gas production. Finally, we apply a lexicon-based textual analysis method to evaluating the news-expressed degree of uncertainty regarding regulations, which captures subjective attitudes of the public towards energy-related regulatory policies. This approach produces a time series measure of regulatory uncertainty about oil and gas production (or in short, oil regulatory uncertainty index), spanning from January 1985 to December 2021.

To explore the economic implications of energy-related regulatory uncertainty, we estimate structural VAR models with the constructed oil regulatory uncertainty measure, oil market variables, and aggregate economic variables. The impulse response functions suggest that an elevated level of oil regulatory uncertainty can lead to a decline in U.S. oil and gas production and drilling activities, as well as economic activity such as industrial production. This negative effect is more evident in the states with higher energy production. For example, an increase in oil regulatory uncertainty is associated with a rise in unemployment rates

[3]The details of the survey are available at the website of the Federal Reserve Bank of Dallas https://www.dallasfed.org/research/surveys/des/2022/2202.aspx#tab-questions. Regarding the question "Which of the following is the primary reason driving uncertainty regarding your firm's outlook?", forty-six percent of executives note that the primary factor driving uncertainty regarding their firms' outlook is "labor shortages, cost inflation and/or supply-chain bottlenecks." Twenty-seven percent cited uncertainty about government regulation, and 20 percent said oil-price volatility. Seven percent said "other," and none noted COVID-19.

in Texas and New Mexico, and this effect is significant and persistent.

Our study connects to three strands of literature. First, an extensive body of literature has demonstrated that economic uncertainty plays an important role in business cycles. Empirical studies generally find a strong countercyclical relationship between real activity and uncertainty (Bloom, 2009; Bloom et al., 2018; Jurado et al., 2015). This paper contributes to this literature by demonstrating that uncertainty around U.S. regulations of the energy sector not only adversely affects oil and gas production, but also has a negative relationship with the overall economic performance.

Second, a growing literature has used textual data to construct novel measures of uncertainty. A seminal work is Baker et al. (2016), which relies on newspaper text and policy- and uncertainty-related keywords to build economic policy uncertainty (EPU) measures. Using similar approaches, subsequent studies have developed other text-based uncertainty measures concerning trade policy, monetary policy, and climate policy (Caldara et al., 2020; Husted et al., 2019; Gavriilidis, 2021). These measures are found to have significant relationships with firm productivity, investment, and stock performance as well as other economic activities (Fasani et al., 2023; Kang et al., 2014; Ren et al., 2022; Ahmed et al., 2021). Our study is closely related to this literature in the sense that we also use newspapers as the source of text data to construct our baseline uncertainty measure, as newspapers have been shown to provide high-frequency, forward-looking information that influences and shapes public opinions (Ter Ellen et al., 2021).

Our study adds to this literature by creating a unique measure focusing specifically on regulatory uncertainty around oil and gas production. Although some existing measures may capture overlapping information with our index, none target the same topic. For example, the EPU index from Baker et al. (2016) measures general policy uncertainty that may affect the economy, and their categorical EPU index on regulation is closely linked to ours but covers a wide range of regulatory issues beyond energy regulation, particularly emphasizing financial regulation (Baker et al., 2016). Climate-related risk and policy uncertainty (Sautner et al., 2023; Gavriilidis, 2021), political risk (Hassan et al., 2019), and geopolitical risk (Caldara and Iacoviello, 2022) also reflect various aspects of the policy and political environment that may influence the energy sector (Su et al., 2021; Gong et al., 2023). However, the uncertainty and risk captured by these measures come from different sources than the oil regulatory uncertainty measured in our study. We compare our measure and other related measures in more detail in Section 2.5, and control for the potential effects of other types of uncertainty in Section 3. Our focus on regulatory uncertainty around oil and gas production allows us to investigate the impact of this particular type of uncertainty on oil production and other economic outcomes.

Third, this paper is related to the literature examining oil market uncertainty. A number of studies investigate oil price uncertainty, which is often measured by expected volatility of future prices of oil or the dispersion of forecasting errors (Kellogg, 2014; Maghyereh et al., 2016; Yin and Feng, 2019; Jo, 2014; Elder and Serletis, 2010). Our study differs from this literature in that our measure mostly represents regulatory uncertainty affecting the supply side of the oil and gas market. This arises from our focus on regulation, as in most cases, regulated entities are firms rather than consumers.

The remainder of this paper is structured as follows. Section 2 discusses the approach to constructing the oil regulatory uncertainty measure, including the text data, NLP methods, and validation and interpretation of the measure. Section 3 presents the empirical analyses conducted to study how oil regulatory uncertainty affects the oil market and the aggregate economy. Section 4 concludes.

2 Measuring Regulatory Uncertainty around Oil and Gas Production

2.1 Newspaper Data

We obtain a corpus of newspaper articles from the U.S. Newsstream database. The database covers historical and current U.S. news content from a wide range of newspapers and other news sources, including but not limited to the New York Times, Wall Street Journal, Washington Post, Los Angeles Times, Chicago Tribune, and Boston Globe. We access the full texts and meta-data of the news articles through ProQuest's Text and Data Mining (TDM) Studio. In our baseline analysis, we use the relevant news content identified using the approach described in Section 2.2 from all newspapers available in U.S. Newsstream. As opposed to using a limited number of individual newspapers, the comprehensive collection of news sources provides a large corpus of news content related to the specific topic of oil and gas production, which consists of 600,953 articles published by hundreds of newspapers. The final corpus used for constructing the regulatory uncertainty index contains 126,238 articles from 358 newspapers published between January 1, 1985 and December 31, 2021. We also use content from select major newspapers only and trade journals as an alternative to construct the index in robustness checks.

2.2 Identifying Relevant News Content

We first identify news articles related to oil and gas production by searching for two groups of terms: (1) subject terms, including "crude oil," "natural gas," "petroleum," "fossil fuel," "energy sector," "energy market," "energy industry," "energy company," and (2) a glossary of oil and gas terms from the U.S. Energy Information Administration (EIA). The second group contains 204 technical terms from the categories of natural gas and petroleum in the EIA glossary (Appendix A). Examples include "oil well," "offshore production", "thermal cracking," and "wellhead." We lemmatize the news articles and terms and use regular expression operations to match the terms, so variants of the terms are captured in the search.[4] We consider a newspaper article related to oil and gas production if it contains at least one term from each of the two groups. We also remove articles with identical full text to a previous article. That results in 600,953 articles from U.S. Newsstream.

To focus on the degree of uncertainty expressed in the news content that discusses regulatory issues, we identify regulation-related content from the aforementioned news articles through a two-step process. First, following the approach of Sinclair and Xie (2021), we extract a "regulatory section" from each article related to oil and gas production. Specifically, a regulatory section consists of at least three consecutive sentences: a sentence containing keywords starting with "regulat" or "deregulat" (e.g., "regulation," "regulator," "deregulation") and its neighboring sentences (i.e., the sentence immediately preceding and following the regulatory sentence). To capture meaningful sentences only, we exclude regulatory sentences that contain five words or fewer. If an article contains multiple regulatory sentences, all such sentences and their neighboring sentences constitute the regulatory section of the article.[5] Articles that do not mention "regulat" or "deregulat" in their body text are excluded from the analysis of regulatory uncertainty. That further refines the corpus to 133,515 oil and gas related articles with regulatory sections.

Although the first step identifies most news content related to regulation concerning oil and gas production, we observe a small number of false positives in the sample. Some regulatory sections, while containing the words "regulation" or "regulate," do not actually refer to government regulation. The second step is to eliminate those cases. To do so, we further apply an advanced NLP technique–zero-shot text classification–to determine whether a regulatory section is about government regulation or not. Zero-shot classification utilizes

[4]Lemmatization removes inflectional endings and returns the base or dictionary form of a word. For example, "regulations" is returned as "regulation," and "regulating" is returned as "regulate." We use spaCy Lemmatizer.

[5]Duplicated sentences are removed if a sequence of a regulatory sentence and its neighboring sentences overlaps with another sequence.

a pre-trained large language model that has been trained on a large amount of text data to associate a piece of text with an appropriate label. In contrast to supervised classification, which can only classify text that belongs to classes in the training data, zero-shot classification can classify text into new, unseen classes Yin et al. (2019). The model we use is *facebook/bart-large-mnli*, one of the most popular pre-trained, transformer-based models for zero-shot classification (Lewis et al., 2019; Williams et al., 2017).[6] The model uses the method proposed by Yin et al. (2019) to classify text using natural language inference. Given a label, the model constructs a hypothesis from the label and estimates the probability that a premise (i.e., a sequence of input text) and the hypothesis match. For example, if we want to determine whether a sequence belongs to the class "politics," we could construct a hypothesis of "This text is about politics," and then the model returns the probability that the sequence belongs to the class Yin et al. (2019).

Table 1: Examples of Zero-shot Classification

	Example 1	*Example 2*
Sequence	The same could be said for the plan announced last week. Defenders of the new regulation predict falling energy costs from renewable sources, but so far, that is pie-in-the-sky speculation. Like the president's prediction that the average family would save $2,500 because of Obamacare.	The fuel filter may need to be replaced or there could be a restriction in the fuel system. A faulty pressure regulator could also be the cause. Bob Weber is an ASE-certified Master Automobile Technician.
Candidate Labels	["government regulation", "not government regulation"]	
Scores	[0.95, 0.05]	[0.002, 0.03]
Regulatory Section	YES	NO

Notes: Example 1 is a quote from a news article published in The Sun on August 9, 2015, and Example 2 is a quote from an article published in Chicago Tribune on April 6, 1997.

To avoid arbitrarily choosing a threshold of label probability, we define the labels in our study with two contradictory classes, ["government regulation", "not government regu-

[6]See more model description at https://huggingface.co/facebook/bart-large-mnli.

lation"], and classify each sequence of a regulatory sentence and its neighboring sentences accordingly to evaluate whether it adds to the regulatory section of an article. We determine that a sequence is relevant if its score for the "government regulation" label is larger than that for the "not government regulation" label. Table 1 shows two examples from our sample. As such, we filter out the false positives from the original corpus of regulatory sections, leaving us with 126,238 news articles containing relevant regulatory sections.

2.3 Quantifying Uncertainty

We quantify uncertainty expressed in the news using a lexicon-based approach. We use the list of uncertainty words from the 2018 version of the Loughran and McDonald (LM) dictionary, which includes 297 words (Loughran and McDonald, 2011). The LM dictionary was constructed specifically for the domain of finance, using a corpus of corporate 10-K reports (Loughran and McDonald, 2011). Because of its domain relevance, the LM dictionary has been frequently used in economic research (for example, Fraiberger (2016); Calomiris et al. (2020); Ostapenko et al. (2020)). The uncertainty category of the LM dictionary covers a broad range of terms expressing uncertainty or imprecision, such as "uncertain," "ambiguity," "confusion," "doubt," and "vague." We calculate an uncertainty score as the proportion of uncertainty words in the text under analysis:

$$s_j^{rs} = \frac{UW_j^{rs}}{TW_j^{rs}} \times 100, \tag{1}$$

where s_j^{rs} is the uncertainty score for the regulatory section of news article j, UW_j^{rs} is the uncertainty word count in the regulatory section based on the LM dictionary, and TW_j^{rs} is the total word count of the regulatory section. For example, the following regulatory section contains three occurrences of uncertainty words: "believe," "may," and "predict", and a total of 74 words. The uncertainty score (s^{rs}) is thus 4.05.

One finding surprised the researchers: Seismic monitoring determined that

> one hydraulic fracture, an induced crack in the shale, traveled 1,800 feet out from the well bore; most traveled just a few hundred feet. The researchers **believe** that fracture **may** have hit naturally occurring faults, and that's something both industry and regulators don't want. "We would like to be able to **predict** those areas" with natural faults and avoid them, Mr. Hammack said.[7]

To measure oil regulatory uncertainty, we estimate uncertainty scores of the regulatory sections from the 126,238 news articles. Of those, 55,862 articles are associated with positive uncertainty scores. In other words, approximately 44 percent of the articles express certain degrees of regulatory uncertainty in the context of oil and gas production. The mean uncertainty score is 0.54, and the standard deviation is 0.82. Appendix B lists ten regulatory sections with the highest uncertainty scores.

To measure changes in uncertainty over time, we construct a monthly index using the estimated uncertainty scores. We follow Shapiro et al. (2020) to use a fixed-effect regression method:

$$s_j^{rs} = u_{t(j)} + v_{i(j)} + \epsilon_j, \tag{2}$$

where $u_{t(j)}$ is a year-month fixed effect, $u_{i(j)}$ is a newspaper fixed effect, and ϵ_j is the error term. The estimated coefficients on the year-month fixed effects compose the monthly oil regulatory uncertainty index. The newspaper fixed effects control for time-invariant heterogeneity across newspapers, which can potentially address the concern of ideological differences among news sources.

2.4 Oil Regulatory Uncertainty Index

Figure 1 displays the time series of the oil regulatory uncertainty index. The index is stationary over time, but with several spikes throughout the period of 1985-2021. The 12-month rolling means illustrate six major spikes in oil regulatory uncertainty over this period,

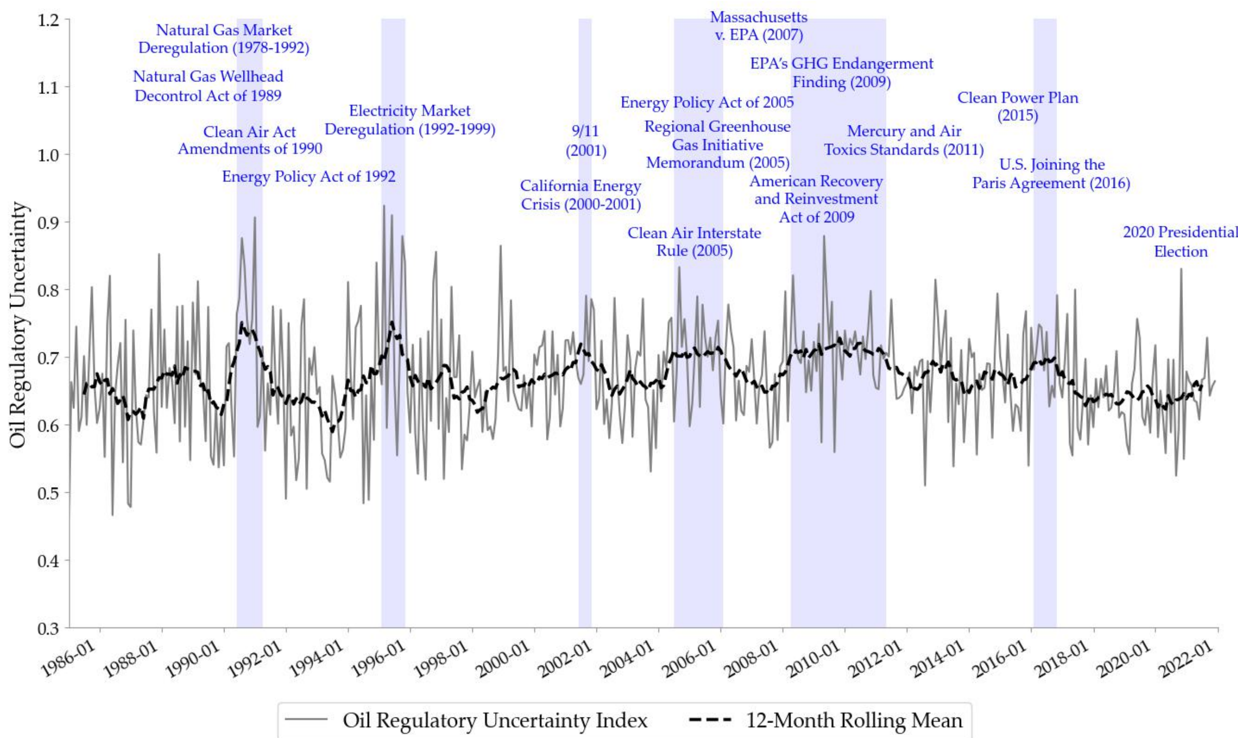
[7]This is an excerpt from the article "Study: Fracking Doesn't Affect Water" published by Pittsburgh Post - Gazette on July 20, 2013.

as shown by the shaded areas. Without implying a causal relationship, Figure 1 annotates important legislative and regulatory developments in the U.S. that possibly contributed to these spikes.

The first spike, around 1990-1991, is likely associated with the natural gas market deregulation that began with the Natural Gas Policy Act of 1978, which aimed to phase out the control of wellhead prices of natural gas. The Natural Gas Wellhead Decontrol Act of 1989 repealed all remaining regulated prices on wellhead sales and completed the process of deregulating the gas sales market (Pierce, 1995). Additionally, the Clean Air Act (CAA) Amendments of 1990 led to major changes in environmental regulations, including new requirements for reducing emissions of sulfur dioxide and nitrogen oxides from fossil-fueled electric power plants (O'Brien, 1997). The spike in 1995 may still reflect the long-standing effects of the implementation of the 1990 CAA Amendments, as well as the deregulation of the electricity market that began in the early 1990s. The 2001 spike in regulatory uncertainty is likely driven by the aftermath of the 9/11 attack, which led to increased focus on energy security. Concurrently, the California energy crisis, characterized by widespread blackouts and market manipulation, led to significant regulatory scrutiny and reforms aimed at stabilizing the electricity market and preventing future crises (Blumstein et al., 2002).

Throughout the 2000s, uncertainty remained heightened as climate change became a central topic in U.S. policy debates. Individual states preceded the federal government to take climate change actions at a regional level, such as the development of the Regional Greenhouse Gas Initiative in 2005, which established the first mandatory cap-and-trade program in the U.S. Such effort increased pressure for a unified national strategy. In 2007, the Supreme Court's landmark decision in *Massachusetts v. EPA* affirmed that the Environmental Protection Agency (EPA) has the statutory authority to regulate greenhouse gas (GHG) emissions under the CAA. This decision set the stage for subsequent federal regulatory actions addressing climate change (Cassedy, 2008). During the Obama administration, the EPA announced its GHG Endangerment Finding in 2009, stating that GHGs endanger the health and welfare of Americans. The same year, Congress passed the American Recovery and Reinvestment Act, which directed massive investments in renewable energy and energy efficiency. Climate change policies continued influencing oil regulatory uncertainty in later years. The spike in 2016 can be attributed to the Clean Power Plan, which was finalized in 2015 and, if implemented, would establish first-ever national standards for carbon emissions from power plants (Fowlie et al., 2014).

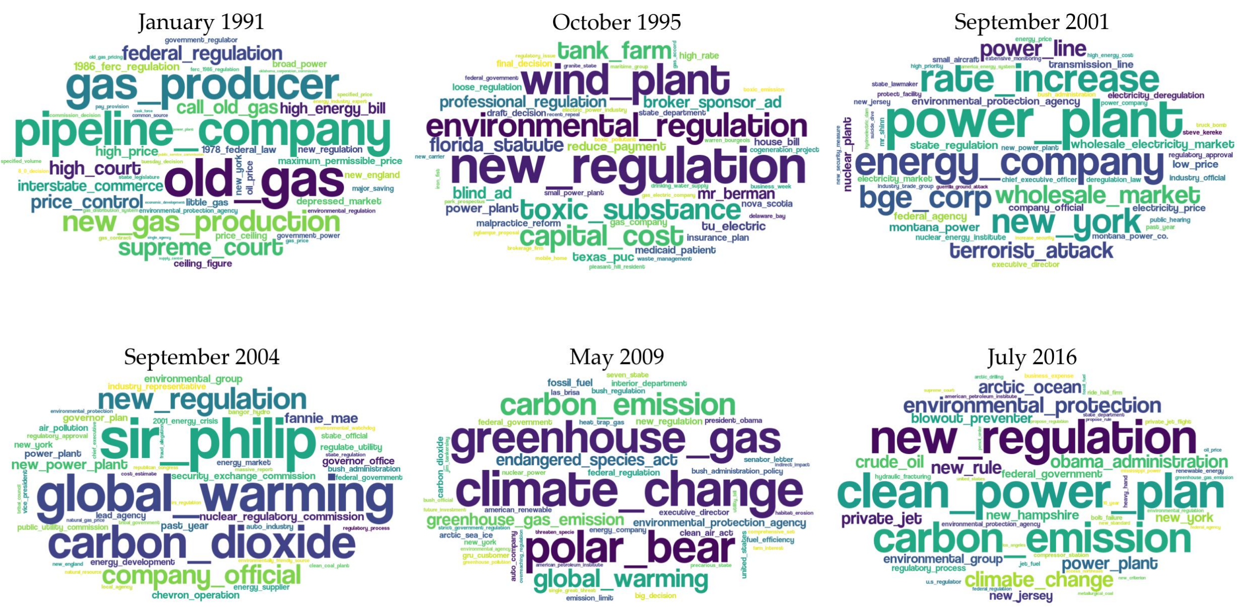
Figure 1: Oil Regulatory Uncertainty Index



Notes: Shaded areas indicate major oil regulatory uncertainty spikes, defined as a time period in which the 12-month rolling mean exceeded 0.7 for at least one month. The 12-month rolling mean is the centered moving average which positions the average value at the 7th month.

To verify our interpretation of the index, we trace back to the news articles with positive uncertainty scores ($s^{rs} > 0$) that were published during the months associated with regulatory uncertainty spikes. One method we use is to generate n-gram word clouds from the regulatory sections of those articles. Figure 2 shows word clouds with the 50 most frequent noun phrases from regulatory sections for a month during each regulatory uncertainty spike.[8] These word clouds reveal that the regulatory sections capture the same legislative and regulatory events annotated in Figure 1. For example, keywords like "gas producer," "old gas," and "pipeline company" in the regulatory sections published in January 1991 indicate relevance to natural gas market deregulation. The regulatory sections from October 1995 mention "environmental regulation," "wind plant," and "toxic substance," reflecting uncertainty around the regulations implementing the 1990 CAA Amendments. Consistent with our interpretation, the word clouds for September 2004, May 2009, and July 2016 all highlight keywords related to climate change, suggesting a connection between U.S. climate policy and increases in oil regulatory uncertainty around those periods. In particular, the clear emphasis on the Clean Power Plan in the July 2016 news illustrates that the impact of a specific rule can be pronounced when other regulatory activities are relatively quiet.

Figure 2: Word Clouds of Regulatory Sections with Positive Uncertainty Scores



Notes: Each word cloud includes 50 most frequent noun chunks from the regulatory sections with positive uncertainty scores ($s^{rs} > 0$) that were published during the corresponding month.

[8] We use spaCy to extract base noun phrases (or "noun chunks") from regulatory sections and plot word clouds using only noun phrases with two or three tokens (i.e., bigrams and trigrams).

2.5 Validation and Interpretation

We have shown that our oil regulatory uncertainty index captures relevant legislative and regulatory developments affecting oil and gas production and isolates the influence of general oil supply uncertainty. However, the approach we use to construct the index is subject to some limitations. First, the lexicon-based method may only identify a limited set of news content related to regulation of oil and gas production. While a supervised machine learning approach could identify a more comprehensive corpus, the lack of training data on this specific topic makes a lexicon-based method the best available choice. Second, like other news-based uncertainty measures, the uncertainty reflected in the news represents the perceptions of journalists, which may be different from those of firms or other stakeholders. Such caveat should be considered when interpreting the indices constructed in this study. Third, although our regulatory index is based on specific languages about regulation (i.e., our regulatory sections), there may be some events that increases both regulatory uncertainty and overall economic uncertainty. We address some of these limitations in this section.

General Oil Supply Uncertainty Index

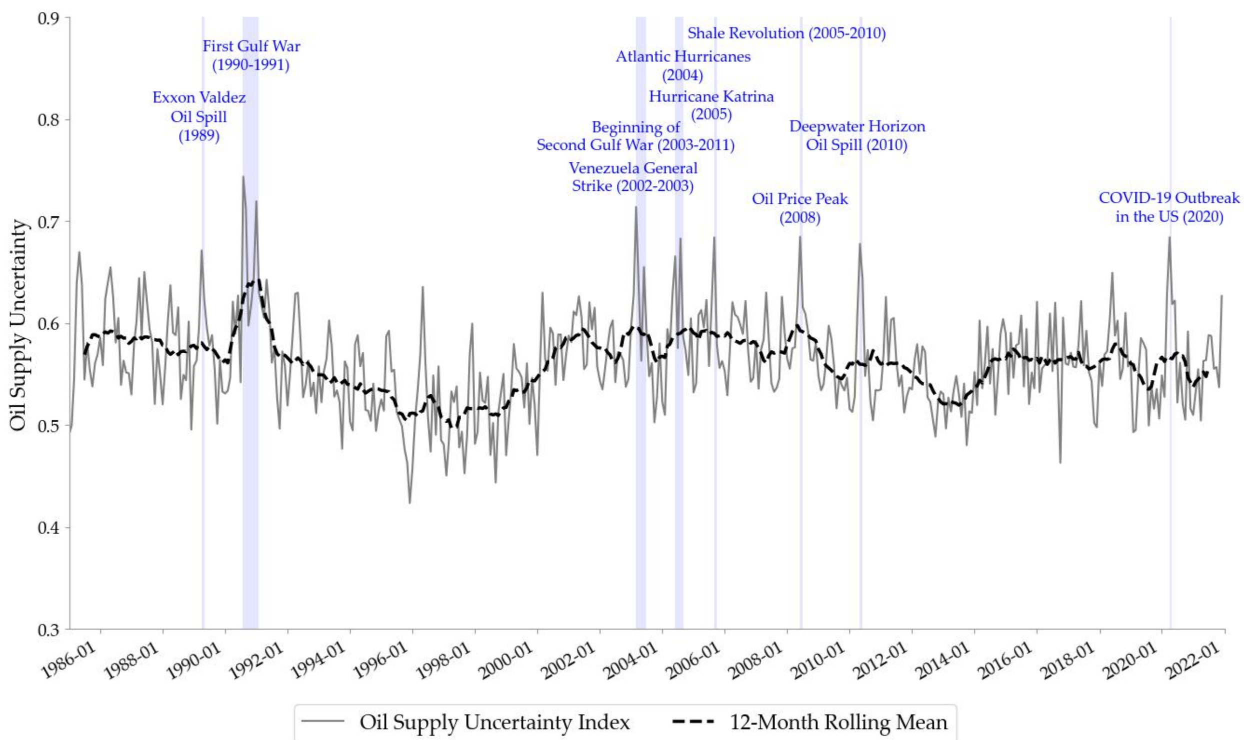
Although the main focus of this paper is to measure regulatory uncertainty around oil and gas production, we also create a general oil supply uncertainty index using the full text of news articles in the same sample as a way to validate our NLP method and the regulatory uncertainty index. We estimate the general oil supply uncertainty index using the same specification as equation (2):

$$s_j^{ft} = u_{t(j)} + v_{i(j)} + \epsilon_j, \tag{3}$$

where $s_j^{ft} = \frac{UW_j^{ft}}{TW_j^{ft}} \times 100$, denoting the uncertainty score calculated from the full text of news article j. Of all the 600,953 oil and gas related articles, 534,778 articles (89 percent) have a positive uncertainty score.

Compared to the regulatory index, the general oil supply uncertainty index captures broad (non-regulatory) historical events that can significantly affect oil and gas industries. As shown in Figure 3, oil supply uncertainty spiked in response to geopolitical events, oil spills, and natural disasters that caused supply disruptions. Those are again verified by the word clouds of noun phrases from news articles published during the months with substantial oil supply uncertainty (Figure 4). Unsurprisingly, oil supply uncertainty peaked at the onset of the Gulf Wars in 1990 and 2003. It also rose sharply in April 1989 and May 2010 due to the Exxon Valdez and Deepwater Horizon oil spills, respectively. Hurricanes also had a tangible impact on oil supply uncertainty, such as the Atlantic hurricanes in 2004 and Hurricane Katrina in 2005.

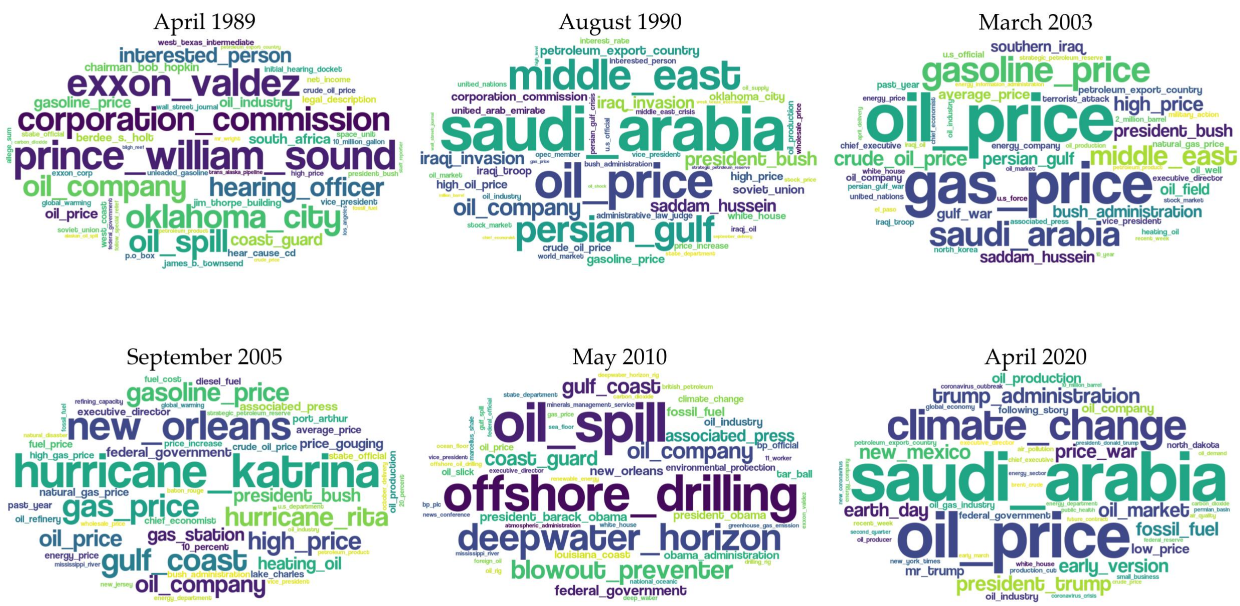
Figure 3: General Oil Supply Uncertainty Index



Notes: Shaded areas indicate major spikes in the monthly oil supply uncertainty index. The 12-month rolling mean is the centered moving average which positions the average value at the 7th month.

The general oil supply uncertainty index helps verify the validity of the oil regulatory uncertainty index in two ways. First, the oil supply uncertainty index captures well-known historical events that affected oil and gas prices and supply. These observations confirm that we can construct a reasonable proxy for uncertainty around oil and gas production using our text-based measurement approach, providing a solid methodological foundation for the measurement of oil regulatory uncertainty. Second, the oil supply uncertainty spikes and associated events are distinct from those captured by the regulatory uncertainty index. Although the two indices co-move during some periods, such as around 1990-1991, the word clouds of the underlying news text suggest that these spikes were driven by different events.[9] The distinct variation between the two indices indicates that our regulatory index indeed measures uncertainty around regulatory issues rather than events influencing oil supply in general.

Figure 4: Word Clouds of Full News Articles with Positive Uncertainty Scores



Notes: Each word cloud includes 50 most frequent noun chunks from the full news articles with positive uncertainty scores ($s^{ft} > 0$) that were published during the corresponding month.

[9]While not depicted in the paper, the word cloud from the regulatory sections published in August 1990 highlights terms including “environmental regulation,” “oilfield waste,” “100,000 barrel,” and “Oklahoma Corporation Commission.” That is distinct from the word cloud for the same month shown in Figure 4, indicating that oil regulatory uncertainty in August 1990 is more relevant to environmental regulations than the Gulf War.

Using a Broader Set of Energy Terms

To check whether the baseline oil regulatory uncertainty index is sensitive to the selection of terms related to oil and gas production, we include more glossaries from the Bureau of Safety and Environmental Enforcement (BSEE) and the Occupational Safety and Health Administration (OSHA) at the U.S. Department of Labor.[10] Combined with the EIA glossary, this broader set of keywords includes 869 terms and generates 651,459 newspaper articles related to oil and gas production, of which 132,368 articles contain regulatory sections. The updated oil regulatory uncertainty index has a very high correlation with the baseline index in Figure 1. The correlation between the two indices is 0.96, which reassures the validity of the keyword set that is used in the construction of the baseline index.

Cross Checking with the Subject Metadata

To verify that our approach identifies news articles that are truly related to oil and gas production, we use the "Subject" entry available in the metadata of news articles. ProQuest assigns subjects to select news articles, which identify the subject matters an article covers. An article can be assigned with one or multiple subjects. For example, an article titled "Decision on Gulf Drilling Puts President on Spot" published by New York Times on April 26, 2001 is assigned with two subjects: offshore drilling and energy policy. While the ProQuest subject metadata provide valuable information on the topics of a news article, the assignment is not available systematically for all articles. For that reason, we do not rely on the subject metadata to construct our baseline index. Instead, we cross check the articles we have identified by matching key terms with the subject data for available articles.

Among the 600,953 news articles that are identified as relevant to oil and gas production, the subject metadata are available for 191,512 articles (32 percent). Of those articles, 179,799

[10]The BSEE glossary contains commonly used terms in oil and gas leasing and exploration activities and is available at https://www.bsee.gov/newsroom/library/glossary. The OSHA glossary is an abridged version of the Dictionary of Petroleum Terms provided by Petex and the University of Texas Austin and is available at https://www.osha.gov/etools/oil-and-gas/glossary-of-terms.

articles (94 percent) are assigned with one or more subjects related to oil and gas production, and only 11,713 (6 percent) are not assigned with such subjects. This confirms that our approach of identifying oil and gas related articles achieves high accuracy, assuming that the subject assignment from ProQuest is reliable.

Using Trade Journals and Magazines

Given that the uncertainty expressed by general news media may differ from the uncertainty experienced and concerned by oil and gas firms, we create an alternative regulatory uncertainty index using trade journals and magazines covering issues related to oil and gas production. The original dataset includes 301,040 articles from 62 U.S. publications published between January 1991 and December 2021.[11] Using the same approach as the baseline, we identify 145,379 articles related to oil and gas production, of which 31,757 articles contain regulatory sections.

Appendix C plots the journal-based index with the baseline. Due to the relatively small number of regulation-related articles each month, the monthly oil regulatory uncertainty index based on the trade journals and magazines is more fluctuating compared to the baseline index. As a result, the two indices have an insignificant correlation of 0.07. However, the 12-month rolling means of the two indices have a statistically significant, moderate correlation of 0.40 and, as shown in Appendix C, co-move during most months over the period of 1991-2021.

Out of the five oil regulatory uncertainty spikes during this period shown in Figure 1, the journal-based index captures three, as illustrated by the shaded areas in Appendix C. The major discrepancies lie in the spikes during the 2004-2005 and 2016 periods. As discussed in Section 2.4, the 2004-2005 spike is possibly related to the state-level climate policies, as well as the Energy Policy Act of 2005 which provided the exemption of hydraulic fracturing from the Safe Drinking Water Act (commonly referred to as the "Halliburton Loophole").

[11]Examples of those publications include Oil Daily, Oil & Gas Journal, Pipeline & Gas Journal, and Oil & Gas Investor. A full list of publications is available upon request.

The 2016 spike is likely a response to the Clean Power Plan. The variations between the two indices around those two spikes may indicate that firms perceive the associated regulatory changes differently than the public (or other stakeholders). For example, the exemption of hydraulic fracturing provides regulatory relief and likely little uncertainty for oil and gas companies, whereas environmentalists and the general public may view it as imposing greater risk to the environment and public health. In addition, firms typically have more complete and accurate information about (and more influence over) the lawmaking and rulemaking processes (Haeder and Yackee, 2015; Acs and Coglianese, 2023). Such information asymmetry could mean that some regulatory changes are more foreseeable for firms than the general public, dampening the level of firm-perceived uncertainty shown in the journal-based index.

Despite these possibilities, the discrepancies between the indices may also be a result of limited data availability. Unlike newspapers, trade journals and magazines are available for various timeframes and frequencies, which may create more inconsistency in the resulting time series. Also for that reason, we prefer using newspapers as the data source for our main analyses.

Using the journal-based index does not change the major conclusions we draw from the empirical analysis in the next section. Results suggest that both news-based and firm-perceived oil regulatory uncertainty have an adverse impact on oil production and oil drilling activities. Empirical results based on this index are shown in Appendix E.1.

Controlling for Economic Uncertainty Scores

To address the concern that our oil regulatory uncertainty index may still capture some events that increase overall economic uncertainty, we take a further step in our NLP method to control for economic uncertainty. Specifically, if an article contains a regulatory section, we further investigate whether the article contains any text discussing the economy. Similar to our definition of a regulatory section, we identify an "economic section" from the article, which consists of at least three consecutive sentences: a sentence containing keywords "economy" or "economic" and its neighboring sentences. We then estimate the uncertainty score of the economic section as a measure of economic uncertainty expressed in the same article.

Among the 126,238 articles with regulatory sections, 46,853 articles (37 percent) contain economic sections, and 23,046 (18 percent) have positive economic uncertainty scores. We set the economic uncertainty score for those articles without economic sections as zero. We add economic uncertainty scores to equation (2) to construct an updated regulatory uncertainty index:

$$s_j^{rs} = w_j + u_{t(j)} + v_{i(j)} + \epsilon_j, \tag{4}$$

where w_j is the economic uncertainty score of article j. The economic-adjusted index is highly correlated with the baseline index, with a correlation of 0.99, indicating that the baseline regulatory index is less likely contaminated by general economic uncertainty.

As shown in Appendix E.2, estimation results based on the economic-adjusted index suggest that oil regulatory uncertainty still negatively affects both oil production and oil drilling activities. However, we acknowledge that this method may not account for all circumstances in which economic uncertainty is discussed. Therefore, we also control for multiple existing measures of economic uncertainty from the literature in our empirical analyses in Section 3.

Comparing with Other Measures

To our knowledge, there is no existing measures that attempt to track regulatory uncertainty specifically around oil and gas production. However, we compare our oil regulatory uncertainty index with several related measures from the literature to see how they differ from each other. Appendix D plots our index with three well-known measures: the EPU index on regulation from (Baker et al., 2016), the geopolitical risk (GPR) index from (Caldara and Iacoviello, 2022), and the climate policy uncertainty (CPU) index from (Gavriilidis, 2021). Due to differences in topical scope, the correlations between the oil regulatory uncertainty index and those three indexes are generally low (less than 0.15). The comparison demonstrates how they capture different types of events.

First, Baker et al. (2016) constructed categorical indexes of their U.S. EPU measure, including a category on regulation. According to the category-specific policy terms used to identify relevant articles in Baker et al. (2016), the regulation EPU index covers a broader set of regulatory issues, with an emphasis on financial regulation. It is thus not surprising that the regulation EPU index peaked in the aftermath of the 2007-08 financial crisis and during the Coronavirus outbreak in April 2020, while our oil regulatory uncertainty index was relatively quiet. Both indices experienced notable surges during the 1990-1991 period, suggesting possible relevance to regulatory changes resulting from the first Gulf War and 1990 CAA Amendments.

Second, the GPR index from Caldara and Iacoviello (2022) measures adverse geopolitical events and associated risks. Its largest spikes occurred around the two Gulf Wars and 9/11. While the oil regulatory uncertainty index had small increases during those periods due to concurrent regulatory changes, the spikes are not as prominent as the GPR index. Since the GPR is not a policy-focused index, it shares more similarities with our general oil supply uncertainty index, as indicated by a higher correlation of 0.36 (compared to 0.11 with the oil regulatory uncertainty index).

Third, given the substantial impact of climate policies on oil and gas production, we also compare our regulatory index with the CPU index from Gavriilidis (2021). Both indices show an increase in uncertainty starting the second half of 2000s, consistent with our interpretation discussed in Section 2.4 that climate change has become a central topic in U.S. policy debate since early 2000s. Given the partisan divide on climate change issues in the U.S., the CPU index appears to be sensitive to presidential transitions, showing particular spikes in response to 2016 and 2020 presidential elections. The CPU remained elevated after November 2016 and reached peaks around important international climate events such as the 2019 UN Climate Action Summit and COP26 in 2021. In comparison, the oil regulatory uncertainty index focuses on U.S. domestic regulatory changes and thus is not as responsive to international debates about climate change as the CPU index.

3 Empirical Analysis

3.1 Empirical Model

In this section, we conduct empirical analyses via structural VAR models to study how regulatory uncertainty about the energy sector affects oil and gas operations. The technical details of the structural VAR model is outlined in Appendix F.

The baseline specification is similar to Ma and Samaniego (2020), in terms of macroeconomic variables and oil market variables. Specifically, the model includes the oil regulatory uncertainty index constructed in this study, log S&P 500 index, federal funds rate, log CPI, log U.S. oil production, log industrial production, log world oil production, world economic activity, and log real oil prices. U.S. oil production is the crude oil production published by EIA. The growth rate of world economic activity is constructed and updated by Kilian (2009). The real oil prices are the CPI-adjusted acquisition cost of U.S. crude oil imports. The baseline model is estimated on monthly data for the periods between 1985m1 and 2021m12.

To recover the orthogonal shocks to regulatory uncertainty about oil and gas production, we use recursiveness identification through Cholesky decomposition with the following ordering:

$$\begin{bmatrix} \textit{oil regulatory uncertainty} \\ \log(\textit{S\&P 500 index}) \\ \textit{federal funds rate} \\ \log(CPI) \\ \log(\textit{U.S. oil production}) \\ \log(\textit{industrial production}) \\ \log(\textit{world oil production}) \\ \textit{world economic activity} \\ \log(\textit{real oil price}) \end{bmatrix}$$

We define an oil regulatory uncertainty shock as the first innovation in the structural VAR model, which means that changes in regulatory uncertainty about the energy sector are able to affect the financial market, the real economy, and oil operational activities contemporaneously. On the other hand, the effects of these variables on oil regulatory uncertainty take at least one period. By doing so, we treat oil regulatory uncertainty innovations estimated from the VAR as most exogenous to the system. This identification strategy is widely used in the literature of uncertainty, such as Bloom (2009), Jurado et al. (2015), and Baker et al. (2016), as well as in the literature of oil uncertainty, such as Ma and Samaniego (2020) and Gao et al. (2022). We include 12 lags of all variables in the baseline VAR so that any trend correlation can be accounted for, which allows us to consistently estimate the impulse responses even using variables in levels.[12]

[12] An limitation, though, with placing variables in this specific order or using 12 lags, is that changes in the variable ordering or number of lags might lead to different results in the impulse response analysis or the interpretation of the results. For robustness, we estimate multiple alternative VAR specifications by ordering oil regulatory uncertainty as the last variable, or using 24 months as the number of lags. Results as shown in Appendices G.1 and G.2 remain similar.

3.2 Estimation Results

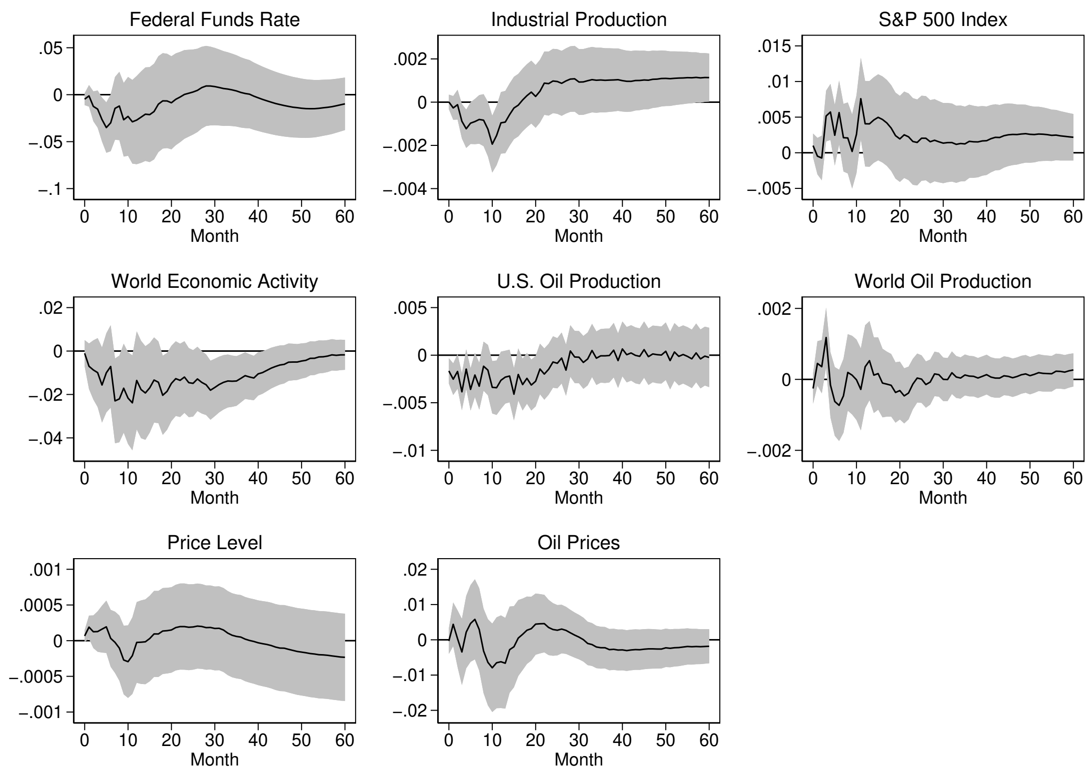
Figure 5 shows the effects of increased uncertainty around U.S. regulations of oil and gas production, represented by the impulse responses to a one-standard-deviation upward shock to the oil regulatory uncertainty index estimated in the baseline model. For this figure and other impulse response figures, solid lines plot the point estimates, and gray areas plot the 68 percent (+/- one standard error) confidence interval, which is constructed using a bootstrap with 2,000 replications. We find that an increase in oil regulatory uncertainty reduces U.S. oil production, while the magnitude is relatively small. World oil production jumps initially but quickly declines and remains at a level lower than the pre-shock trend. Oil prices, on the other hand, do not significantly respond to the shock. Economic activities scale down, with slight declines in both industrial production and world economic activity.[13]

One may be curious about how oil and gas drilling activities are affected by uncertainty about regulations of the energy sector, as regulatory uncertainty may affect oil and gas producers' longer-term plans. This can in turn affect oil and gas drilling contracts and operations more significantly than oil production on existing facilities. To shed light on this question, we estimate an alternative structural VAR model where U.S. oil production is replaced by U.S. oil drilling while all the other variables remain unchanged as in the baseline model. Impulse responses are shown in Figure 6.

We find that oil regulatory uncertainty has indeed more significantly negative effects on U.S. oil drilling for up to 2 years after the initial impact. This may be explained by oil producers' "wait and see" behavior. When facing uncertainty about regulatory policies of the energy sector, oil production firms may delay or even reduce their investment on new projects, and therefore, new contracts or existing operations of drilling wells can be cancelled or suspended, leading to a decline in oil and gas drilling activities. As for economic activities, the response of output is similar to Figure 5 where oil production is included in the model.

[13] Results are similar when we estimate VAR models by ordering regulatory uncertainty as the last variable or using stationary detrended variables.

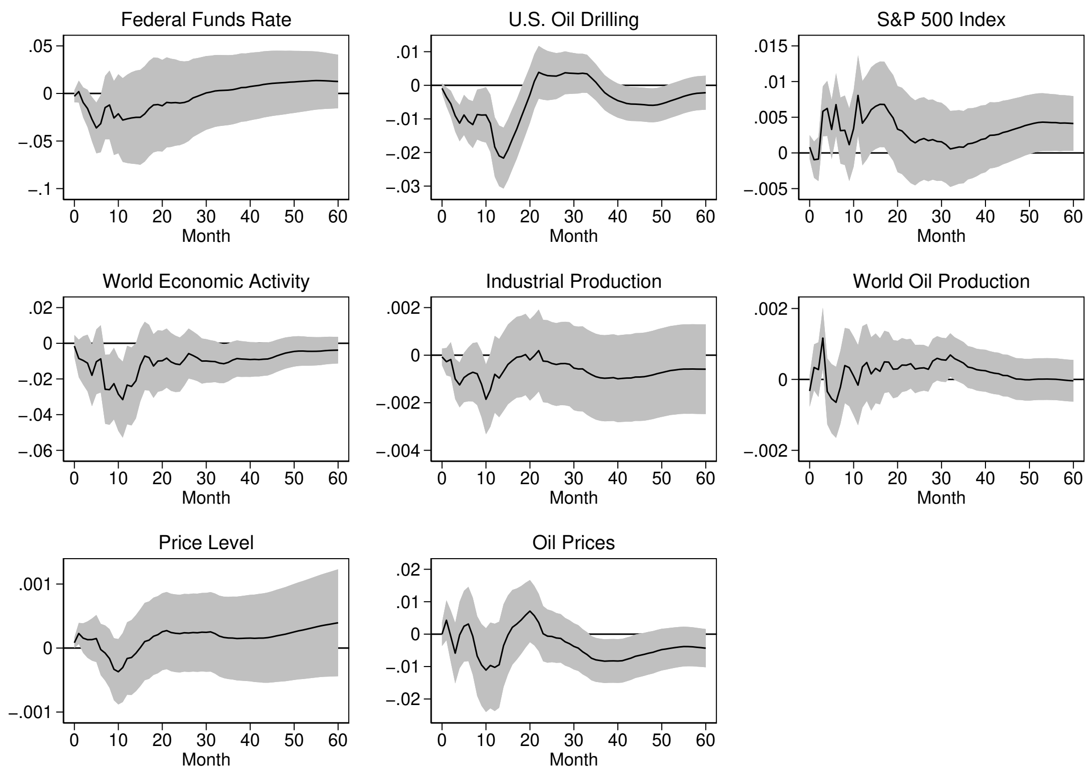
Figure 5: The Impact of Oil Regulatory Uncertainty Shocks, with Oil Production



Notes: The figure plots impulse responses to a one-standard-deviation upward shock to oil regulatory uncertainty, estimated using the baseline VAR model. Solid lines indicate point estimates, and gray areas show 68 percent confidence intervals.

For robustness checks, we first include other types of aggregate uncertainty measures as an additional control variable, such as economic uncertainty (Jurado et al., 2015), economic policy uncertainty (Baker et al., 2016), climate policy uncertainty (Gavriilidis, 2021), or geopolitical risk (Caldara and Iacoviello, 2022). We put these uncertainty measures as the first variable in the baseline VAR model so that they can potentially affect oil regulatory uncertainty contemporaneously. These exercises allow us to isolate the pure effects of oil regulatory uncertainty from other types of uncertainty that may also affect oil company operations. Results in Appendices G.3-G.7 show that oil regulatory uncertainty still leads to declines in oil production and oil drilling activities, even when accounting for the potential effects of other uncertainty. Additionally, using the local projection method (Jordà, 2005)

Figure 6: The Impact of Oil Regulatory Uncertainty Shocks, with Oil Drilling



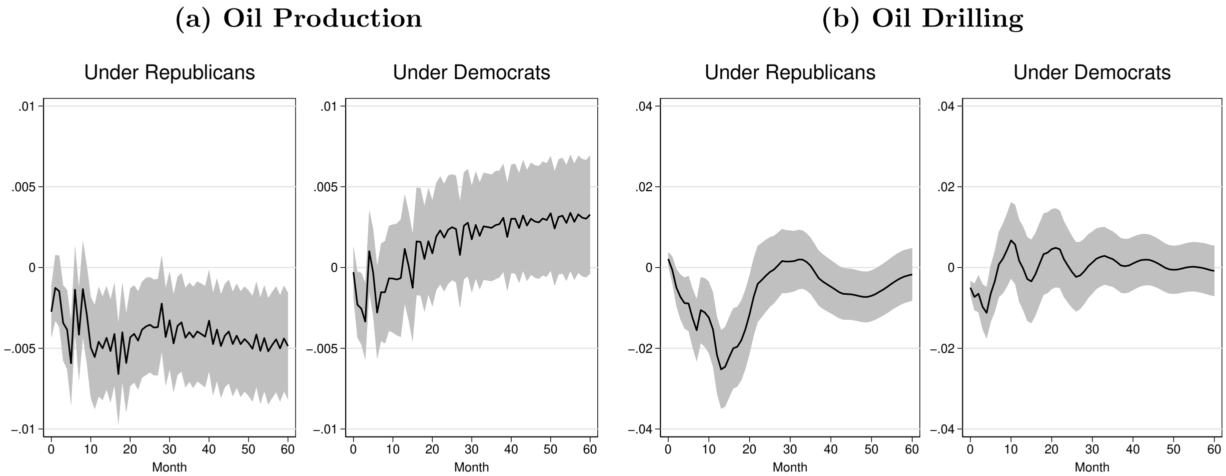
Notes: The figure plots impulse responses to a one-standard-deviation upward shock to oil regulatory uncertainty, estimated using the baseline VAR model but replacing U.S. oil production with oil drilling. Solid lines indicate point estimates, and gray areas show 68 percent confidence intervals.

on the baseline model specification also delivers similar findings, as shown in Appendix H.

Political Influence

Another interesting question is whether the impact of oil regulatory uncertainty on oil production and oil drilling varies depending on the political party in power. To address this question, we introduce to the baseline VAR model an interaction term between the oil regulatory uncertainty index and a dummy variable, which equals 1 when the U.S. president is a Republican and 0 when a Democrat is in office. Figure 7 shows the estimated impulse responses to an increase in oil regulatory uncertainty under Republican and Democratic administrations, respectively. Both oil production and drilling are more negatively affected by heightened uncertainty in the short run when a Republican is in power. This may be attributed to the generally less regulatory approach of Republican administrations; thus, any uncertainty surrounding their oil regulatory policies tends to be more economically relevant and significant than that associated with Democratic administrations.

Figure 7: The Impact of Oil Regulatory Uncertainty Shocks under Different Political Parties

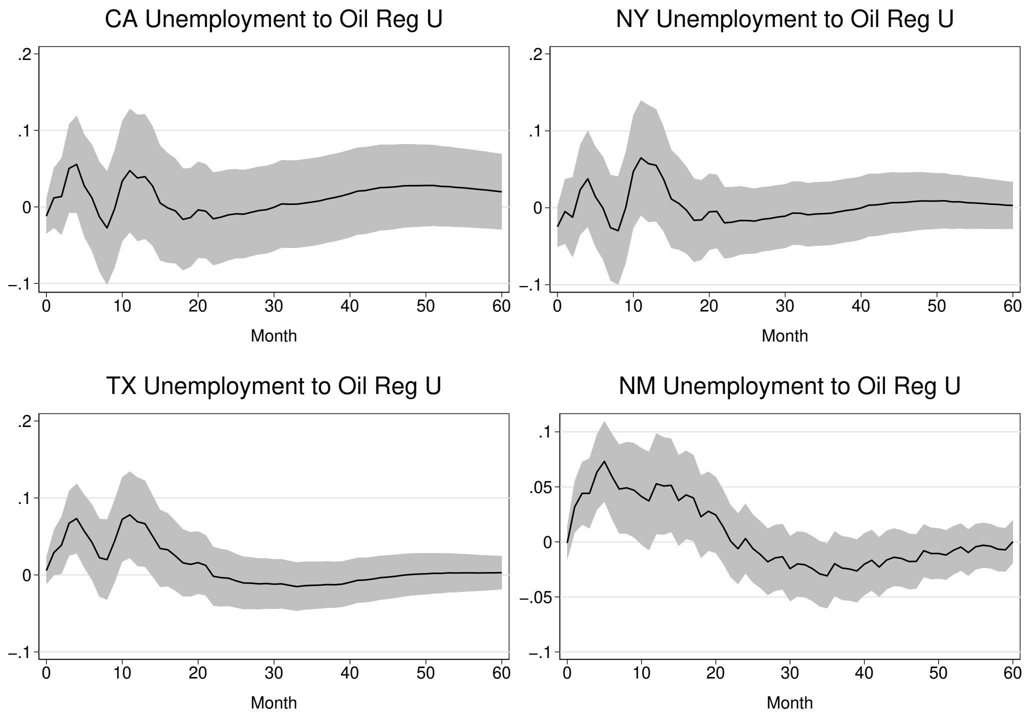


Notes: The figure plots the responses of oil production and oil drilling to a one-standard-deviation shock to oil regulatory uncertainty under Republican and Democratic administrations. Solid lines indicate point estimates, and gray areas show 68 percent confidence intervals.

State-level Variation

Finally, to explore whether oil regulatory uncertainty may have different effects on U.S. states with different levels of oil production activities, we re-estimate the baseline model with an additional aggregate variable that reflects overall economic conditions of states with different levels of oil-related activities. In particular, we use the state-level unemployment rate in the states with the highest GDP, California and New York, and in the states with the highest oil production in 2022, Texas and New Mexico. The results are shown in Figure 8. Among the four states, unemployment rates in Texas and New Mexico are more significantly and adversely affected by an increase in oil regulatory uncertainty. This finding is not surprising, as oil and gas production is a more dominant industry in Texas and New Mexico than in the other states considered in this exercise.

Figure 8: The Impact of Oil Regulatory Uncertainty Shocks on Various States



Notes: The figure plots the impulse responses of unemployment rates in different states to a one-standard-deviation shock to oil regulatory uncertainty. Solid lines indicate point estimates, and gray areas show 68 percent confidence intervals.

4 Conclusion

In this study, we construct a news-based measure of regulatory uncertainty around the energy sector. We employ a large corpus of news articles published by hundreds of U.S. newspapers from 1985 through 2021 and identify news content related to regulations governing primarily oil and gas exploration, production, and refining. We quantify the level of uncertainty expressed in the news content using a lexicon-based textual analysis method and develop a monthly index of regulatory uncertainty about oil and gas production.

Using structural VARs, we examine the economic impact of increased oil regulatory uncertainty. Impulse responses suggest that an increase in oil regulatory uncertainty reduces oil production and drilling activities as well as economic activity such as industrial production. These results are robust to various modification of the empirical model including controlling for other types of uncertainty and using the local projection method. Moreover, the negative impact of oil regulatory uncertainty on oil production and drilling is more prominent under a Republican administration than under a Democratic administration, indicating potential influences of the U.S. political environment. Finally, we find that higher oil regulatory uncertainty also has significant, persistent adverse effects on employment in large energy-producing states such as Texas and New Mexico.

Our research has several policy implications. First, the study underscores the significant impact that uncertainty about U.S. regulatory policies in the energy sector can have on oil production and oil drilling operations, indicating that instability in regulatory environments can deter investment and disrupt oil sector performance. Moreover, the research reveals that the negative effects of regulatory uncertainty extend beyond the energy sector, especially affecting economic outcomes in states with a larger energy sector. This highlights the importance of a predictable regulatory environment, i.e., inconsistent or ambiguous regulatory changes can lead to broader, negative economic consequences. Therefore, when developing future regulatory policies, policymakers should prioritize clear and transparent communication and establish predictable regulatory frameworks to mitigate the negative impacts of uncertainty.

A future extension of this study is to distinguish different types (or sources) of regulatory uncertainty related to the energy sector. Does increased uncertainty come from unanticipated new regulations or ambiguous guidance on the implementation of existing regulations? Does it relate to the volume or strictness of energy regulation? Is it associated with political turbulence or economic downturns? Such analysis could further clarify how oil regulatory uncertainty affects the energy sector and other economic outcomes and lead to actionable policy recommendations. Future research could also examine how oil regulatory uncertainty influences firm-level decisions and outcomes. Our study manifests the "wait-and-see" effect by showing that increased regulatory uncertainty leads to a decline in oil drilling activities. Potential research could investigate the other mechanisms in which regulatory uncertainty may affect oil and gas firms' investment and hiring decisions.

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Appendices

(For Online Publication)

A Key Terms for Identifying Relevant News Content

Group 1: Subject Terms

“crude oil”, “natural gas”, “petroleum”, “fossil fuel”, “energy sector”, “energy market”, “energy industry”, “energy company”

Group 2: EIA Glossary of Terms

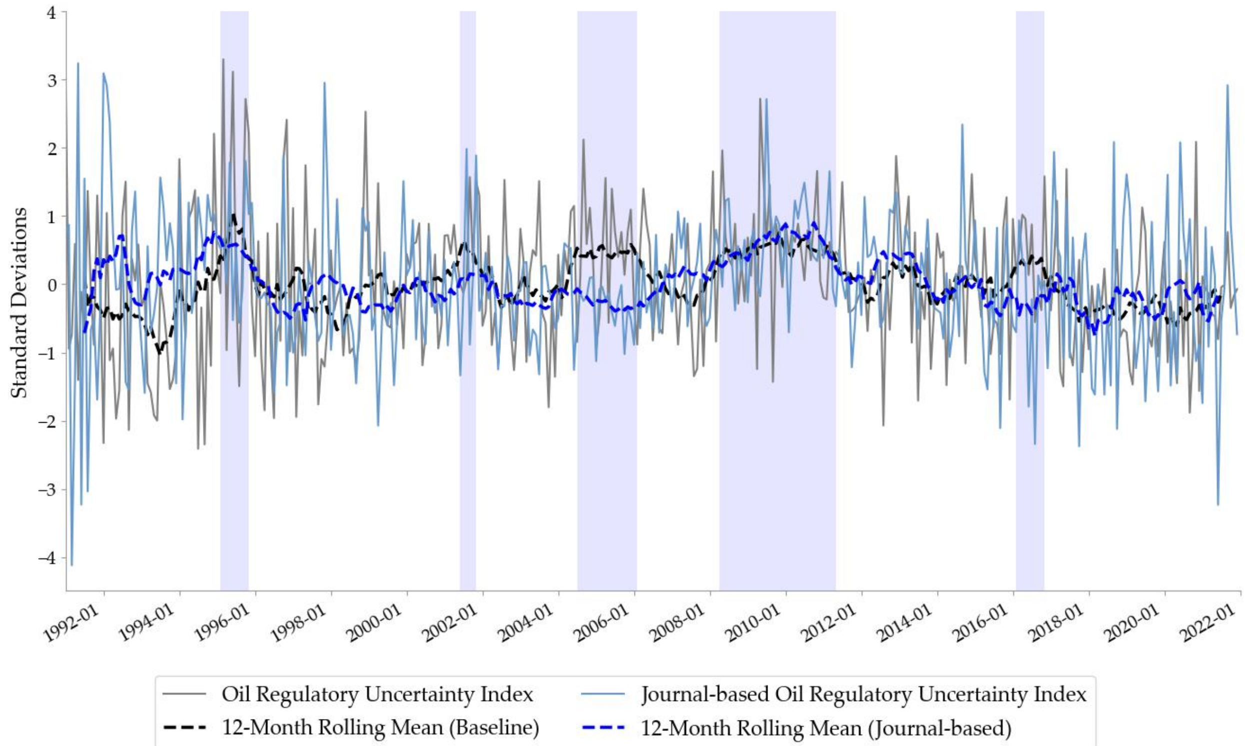
“atmospheric crude oil distillation”, “base gas”, “benzene”, “blending plant”, “bonded petroleum imports”, “bulk station”, “bulk terminal”, “c6h6”, “cng”, “captive refinery oxygenate plants”, “catalytic cracking”, “catalytic hydrocracking”, “catalytic hydrotreating”, “catalytic reforming”, “charge capacity”, “coke oven gas”, “compressed natural gas”, “condensate”, “conventional gasoline”, “crude oil acquisitions”, “crude oil losses”, “crude oil production”, “crude oil qualities”, “crude oil stream”, “delayed coking”, “delivered gas”, “denatured ”, “depleted storage field”, “desulfurization”, “diesel fuel”, “disposition”, “distillate”, “distillate fuel oil”, “domestic crude oil”, “drilling”, “dry natural gas”, “dry natural gas production”, “emissions”, “ending stocks”, “energy operation”, “environmental protection”, “environmental restoration”, “environmental restrictions”, “exploration drilling”, “extraction loss”, “field production”, “first purchase”, “flare”, “flexicoking”, “fluid coking”, “fresh feed input”, “fuel oil”, “fuel ethanol”, “fuels solvent deasphalting”, “gas condensate well gas”, “gas formation volume factor”, “gas plant operator”, “gas well”, “gasohol”, “gasoline blending components”, “gross withdrawals”, “group 3”, “hgl”, “hsd”, “heavy gas oil”, “high sulfur diesel fuel”, “hydraulic fracturing”, “hydrocarbon gas liquids”, “imported crude oil burned as fuel”, “intransit deliveries”, “intransit receipts”, “isopentane”, “kerogen”, “kerosene”, “lng”, “lpg”, “lrg”, “lease condensate”, “lease fuel”, “lease separator”, “light gas oils”, “liquefied natural gas”, “liquefied petroleum gases”, “liquefied refinery gases”, “liquid fuels”, “marketed production”, “merchant oxygenate plants”, “middle distillates”, “miscellaneous petroleum products”, “ngl”, “ngpa”, “ngpl”, “native gas”, “natural gas liquids”, “natural gas policy act”, “natural gas used for injection”, “natural gas field facility”, “natural gas gross withdrawals”, “natural gas hydrates”, “natural gas lease production”, “natural gas liquids production”, “natural gas marketed production”, “natural gas marketer", "natural gas plant liquids", "natural gas plant liquids production", "natural gas processing plant", "natural gas production", "natural gas utility demand-side management program sponsor", "natural gasoline", "nonhydrocarbon gases", "opec", "oprg", "offshore production", "offshore reserves", "oil field", "oil well", "olefinic hydrocarbons", "operable utilization rate", "operating capacity", "operating utilization rate", "organization of petroleum exporting countries", "organization of the petroleum exporting countries", "original gas-in-place", "original oil-in-place", "outer continental shelf", "oxygenated gasoline", "pad districts", "padd", "paraffinic hydrocarbons", "pentanes plus", "persian gulf", "petrochemical feedstocks", "petroleum administration for defense district", "petroleum and other liquids", "petroleum coke", "petroleum consumption", "petroleum imports", "petroleum jelly", "petroleum products", "petroleum refinery", "petroleum stocks", "pipeline", "pipeline fuel", "plant condensate", "prime supplier", "product supplied", "production", "propane", "propane air", "proved energy reserves", "rack sales", "recovery factor", "refiner", "refinery", "refinery gas", "refinery input", "refinery olefins", "refinery production", "refinery yield", "reformulated gasoline", "repressuring", "residual fuel oil", "residuum", "road oil", "sng", "spr", "shale gas", "shell storage capacity", "still gas", "storage", "strategic petroleum reserve", "supplemental gaseous fuels supplies", "supply", "synthetic natural gas", "tame", "tank farm", "tanker and barge", "thermal cracking", "tight oil", "total natural gas storage field capacity", "unaccounted for", "underground natural gas storage", "underground natural gas storage injections", "underground storage withdrawals", "unfinished oils", "unfractionated streams", "unit value", "vacuum distillation", "vented natural gas", "visbreaking", "wti", "wellhead", "wellhead price", "west texas intermediate", "working gas", "working storage capacity", "design capacity", "heating oil", "lease", "olefins", "plant fuel", "refinery receipts", "unfinished oil acquisitions", "wet after lease separation"

B Articles with the Highest Regulatory Uncertainty Scores

Newspaper	*Publication Date*	*Regulatory Section*	*Uncertainty Score*
Pittsburgh Post - Gazette	12/19/2005	I believe in integrity. I believe in a minimum of regulations. I don't believe in high taxes.	16.7
Wall Street Journal (Online)	9/18/2013	In turn, her re-election next year could hinge on whether she backs President Obama's controversial pick to oversee the nation's electric grid and pipelines. The confirmation of Ron Binz to head the Federal Energy Regulatory Committee may hinge on Louisiana Sen. Mary Landrieu's support.	8.3
Times News	8/18/2011	Other countries may not have the same environmental regulations that we have. Recycling can create jobs. Bauxite and petroleum may not be mined domestically.	8.3
Sentinel & Enterprise; The Sun	8/9/2015	The same could be said for the plan announced last week. Defenders of the new regulation predict falling energy costs from renewable sources, but so far, that is pie-in-the-sky speculation. Like the president's prediction that the average family would save $2,500 because of Obamacare.	8.2
The Register - Guard	8/11/2007	The state does own the terrestrial sea, which extends from shore out to three miles, and there are myriad state regulations that could apply to wave energy companies. And it remains unclear how much input the state could have when it comes to wave energy. But any comprehensive plan may be tough to fashion, given the confusion about who's really in charge.	7.9
Nashville Banner	1/3/1997	The possibility the city could lose its ability to require haulers to take their garbage to the thermal plant. The EPA is said to be already working on the new regulations. The possibility of a second upgrade in 2009.	7.7
New York Times; Pittsburgh Post - Gazette	9/6/2001; 9/9/2001	They might include the frail elderly, whose health is at particular risk on very hot days. Or they could be industries, like power companies. Defendants could be federal agencies like the Environmental Protection Agency or the Energy Department, for subsidizing the use of fossil fuels or accused of failing to regulate emissions.	7.7

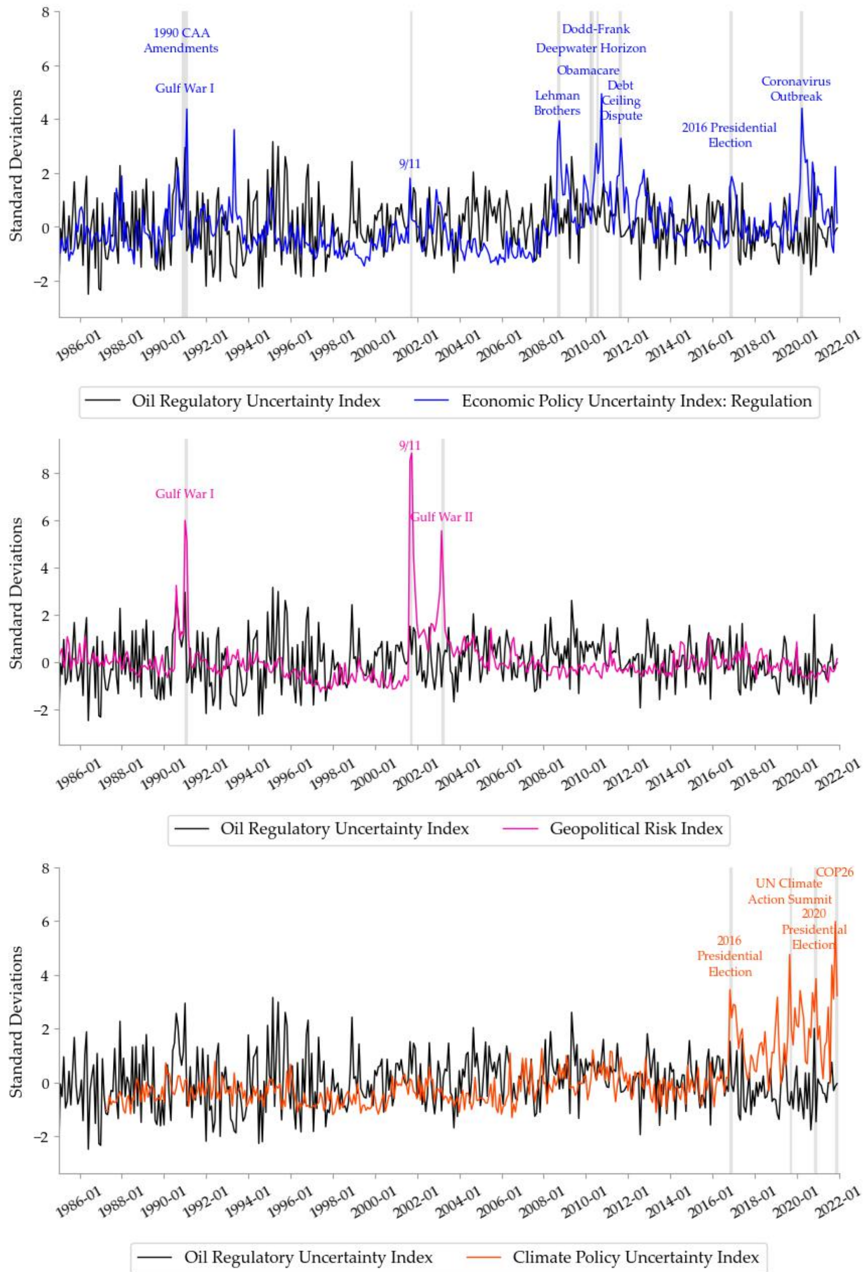
St. Louis Post - Dispatch	8/25/2000	Until now, motor carriers that move passengers or hazardous materials could be shut down if they got poor ratings, but regular cargo shippers could not. Trucking companies may be shut down over safety Trucking companies that get unsatisfactory safety ratings from federal regulators could be shut down under new rules announced Thursday by the Transportation Department. Currency may be confiscated from those who don't.	7.6
Wall Street Journal (Online)	1/20/2016	While that may boost volatility for now, it ultimately may prove beneficial. He said in an interview in Davos that it can be risky to buy in an environment like this. Hedge-fund manager Paul Singer, who runs the roughly $26 billion Elliott Management Corp., said his fear is more monetary stimulus, in lieu of longer-term fixes such as easing tax and regulatory burdens.	7.6
Los Angeles Times	9/18/2005	As for the closed-end funds that buy the infrastructure stocks, the biggest risk may be that they might not invest well enough to justify the management fees they're charging. But that doesn't seem like much of a risk for the time being. Finally, in the case of pipelines, they're regulated either by the federal government or state entities, so there's always regulatory risk (but also a regulatory assurance of a set return from the business).	7.5

C Comparing Baseline Oil Regulatory Uncertainty Index with Journal-based Index



Notes: Both indices are normalized to have mean equal to zero and standard deviation equal to one. Shaded areas indicate the same uncertainty spikes as those shown in Figure 1.

D Comparing Oil Regulatory Uncertainty Index with Other Measures

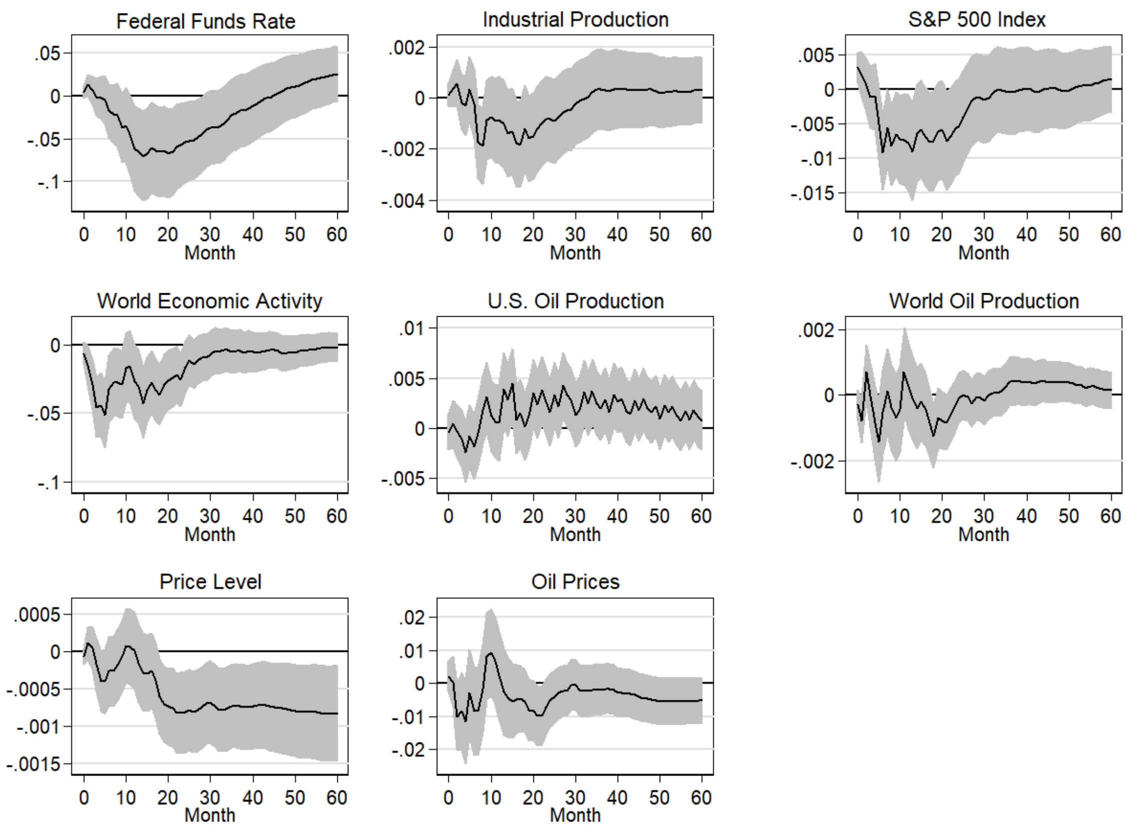


Notes: All indices are normalized to have mean equal to zero and standard deviation equal to one.

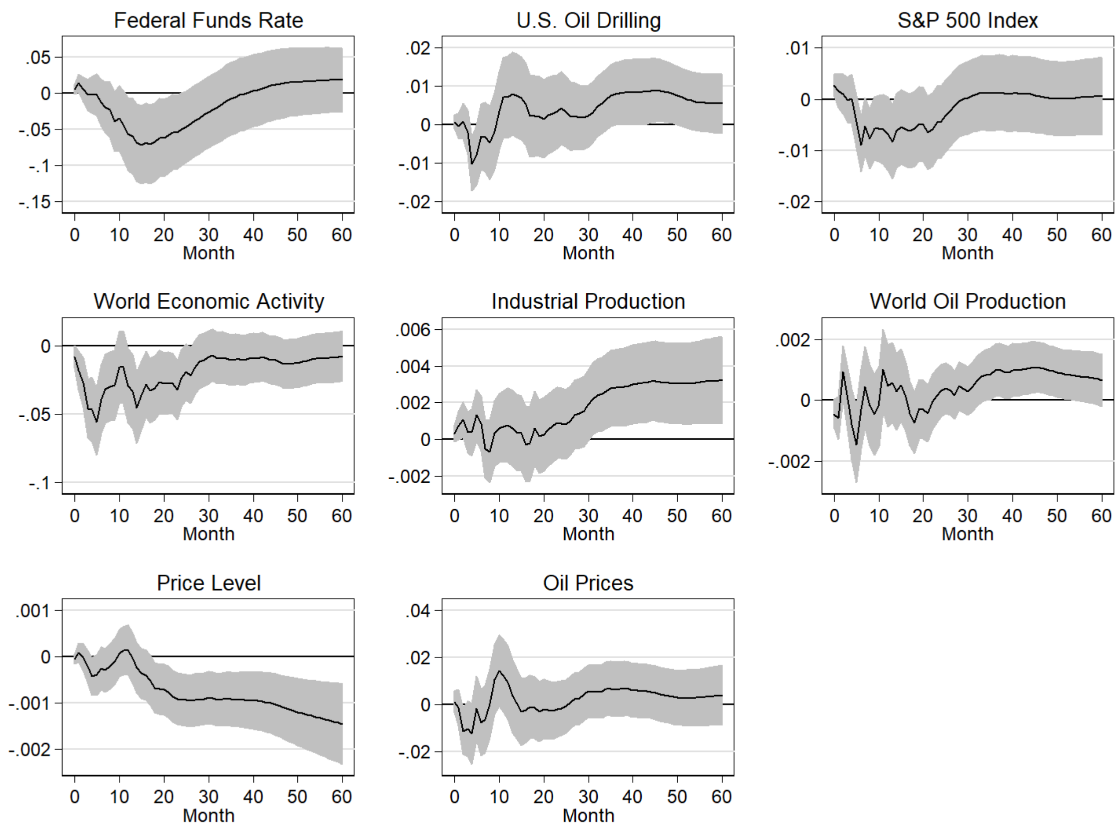
E The Impact of Oil Regulatory Uncertainty Shocks, Using Alternative Indices

E.1 Using Journal-based Index

E.1.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production

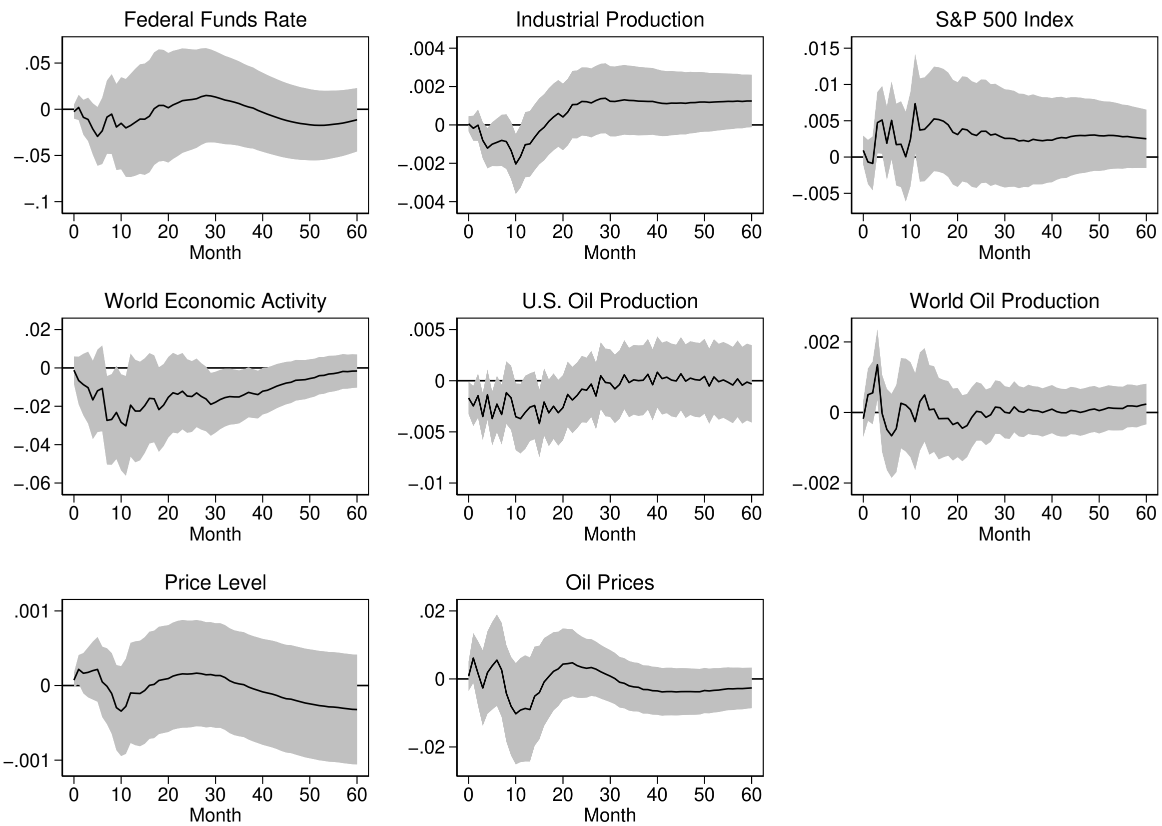


E.1.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling

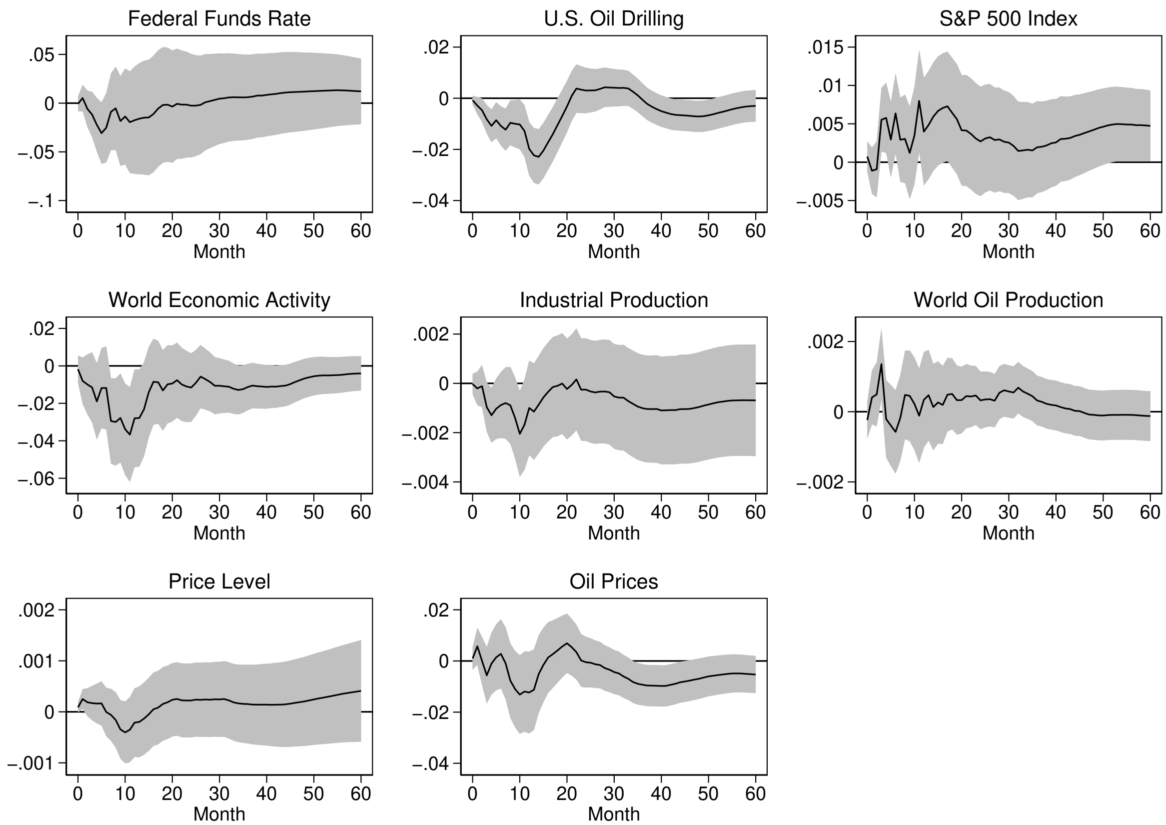


E.2 Using Economic-adjusted Index

E.2.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production



E.2.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling



F Structural VAR model

The baseline structural VAR model can be specified as:

$$\mathbf{A_0 Y_t} = \mathbf{B_1 Y_{t-1}} + \mathbf{B_2 Y_{t-2}} + ... + \mathbf{B_p Y_{t-p}} + \mathbf{e_t}$$

where $\mathbf{A_o}$ is an n×n matrix that captures the contemporaneous relationships among the endogenous variables $\mathbf{Y_t}$, $\mathbf{B_i}$ (for i = 1, 2, ..., p) are n×n matrices that capture the lagged effects from the endogenous variables with p as the number of lags, $\mathbf{e_t}$ is an n×1 vector of structural shocks. To estimate the model, we rewrite the structural VAR model in a reduced form as follows:

$$\mathbf{Y_t} = \mathbf{A_1 Y_{t-1}} + \mathbf{A_2 Y_{t-2}} + ... + \mathbf{A_p Y_{t-p}} + \mathbf{u_t}$$

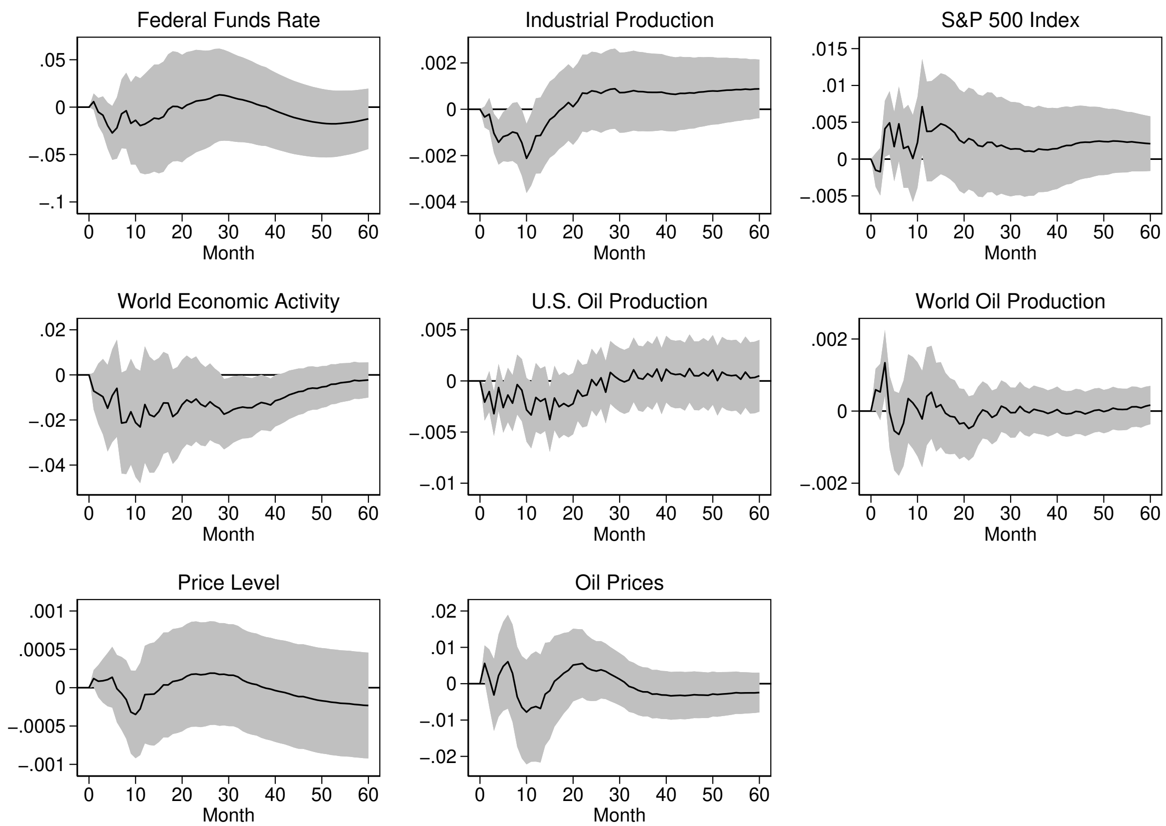
where $\mathbf{u_t} = \mathbf{A_0^{-1} e_t}$ is reduced form shocks.

The baseline identification scheme for structural shocks $\mathbf{e_t}$ is the Cholesky decomposition method. First, we obtain the residuals $\mathbf{u_t}$ from the reduced form estimation, and calculate its covariance matrix $\mathbf{\Sigma_u}$ from $\mathbf{\Sigma_u} = \frac{1}{T}\sum_{T=1}^{\infty} \mathbf{u_t u_t'}$. Next, we apply the Cholesky decomposition to decompose this covariance matrix into a lower triangular matrix $\mathbf{L}$ such that $\mathbf{\Sigma_u} = \mathbf{LL'}$. $\mathbf{L}$ is a candidate for $\mathbf{A_0}$, and we set $\mathbf{A_0} = \mathbf{L^{-1}}$. Finally, we can obtain the structural innovations $\mathbf{e_t}$ from the reduced form innovations $\mathbf{u_t}$ by $\mathbf{e_t} = \mathbf{A_0 u_t}$. Once we have the structural shocks, we can calculate the impulse response functions, which are the main tool to show the effects of the structural shocks.

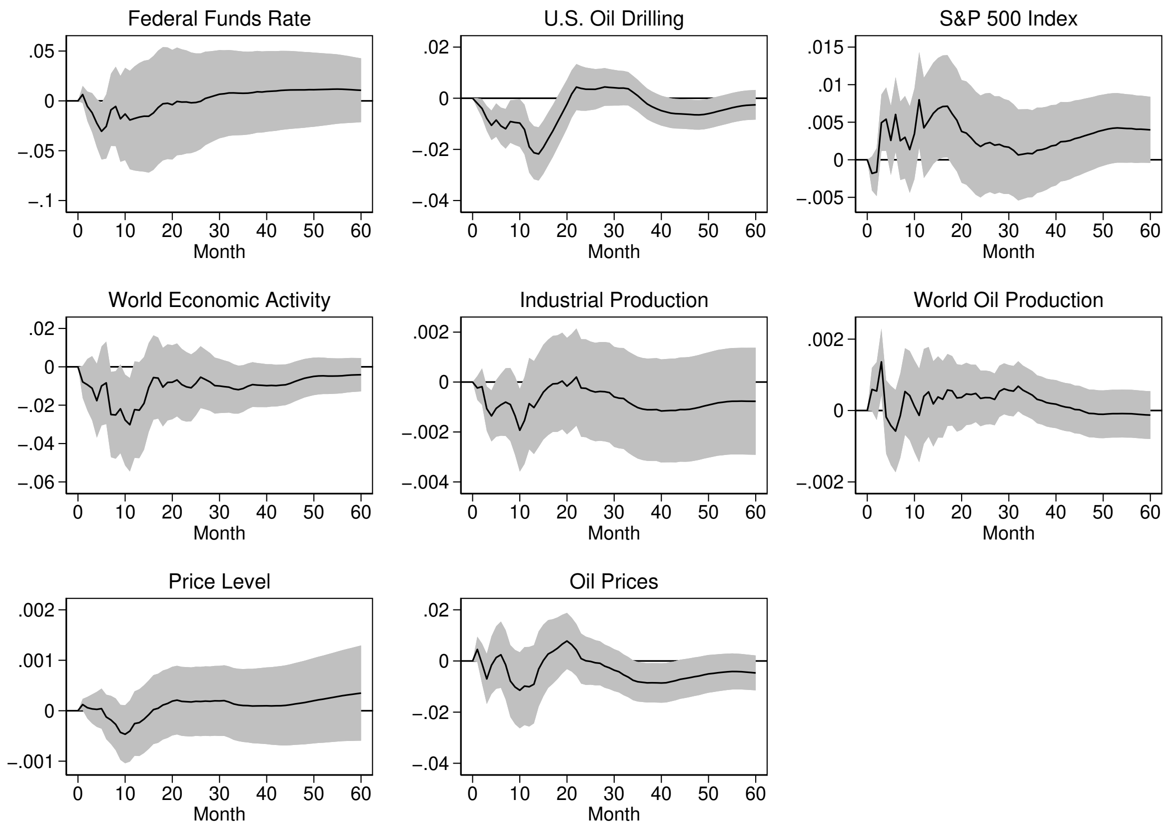
G Robustness: The Impact of Oil Regulatory Uncertainty Shocks

G.1 Ordering Oil Regulatory Uncertainty as the Last Variable

G.1.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production

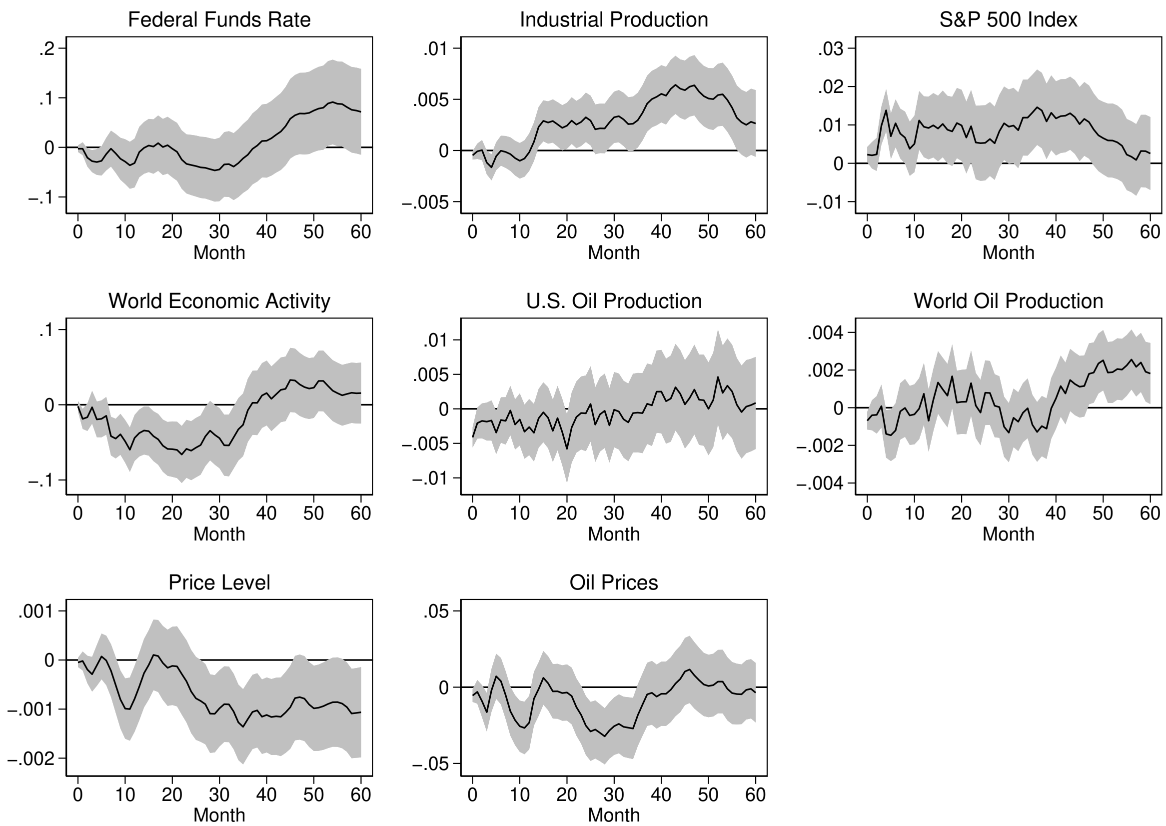


G.1.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling

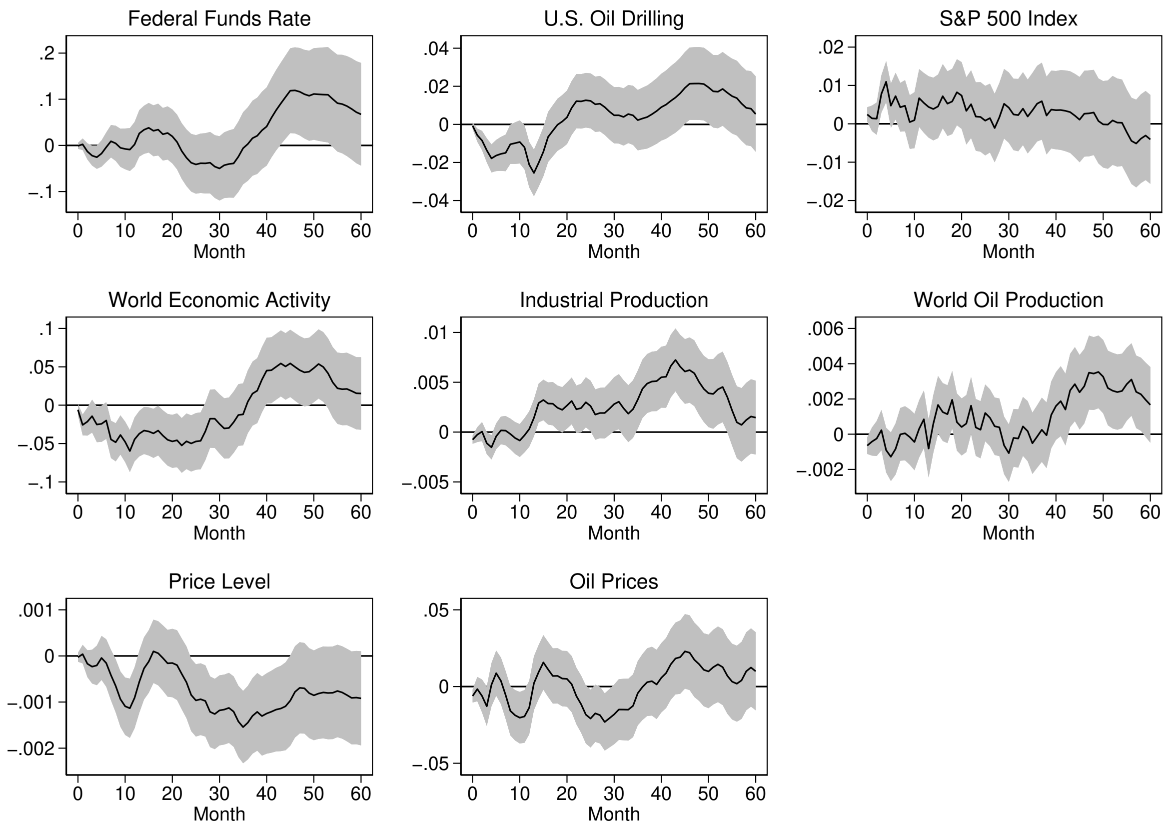


G.2 Using 24 Lags

G.2.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production

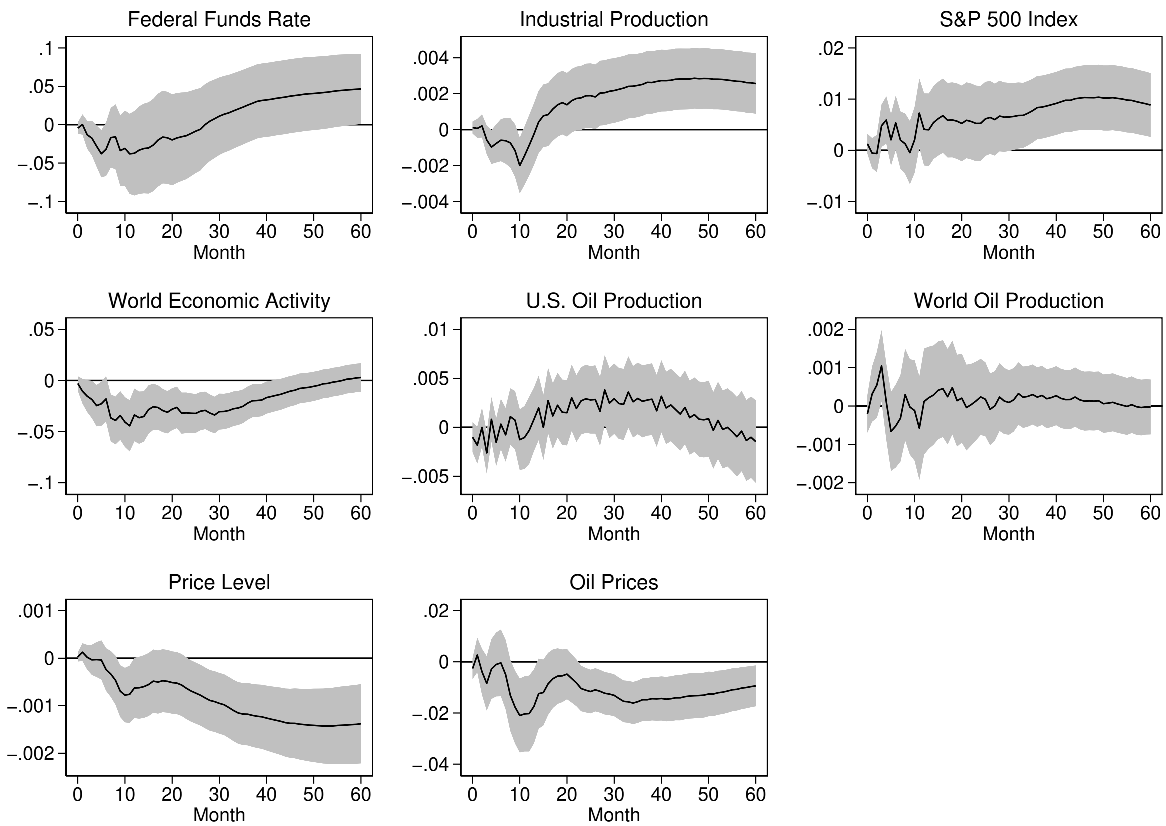


G.2.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling

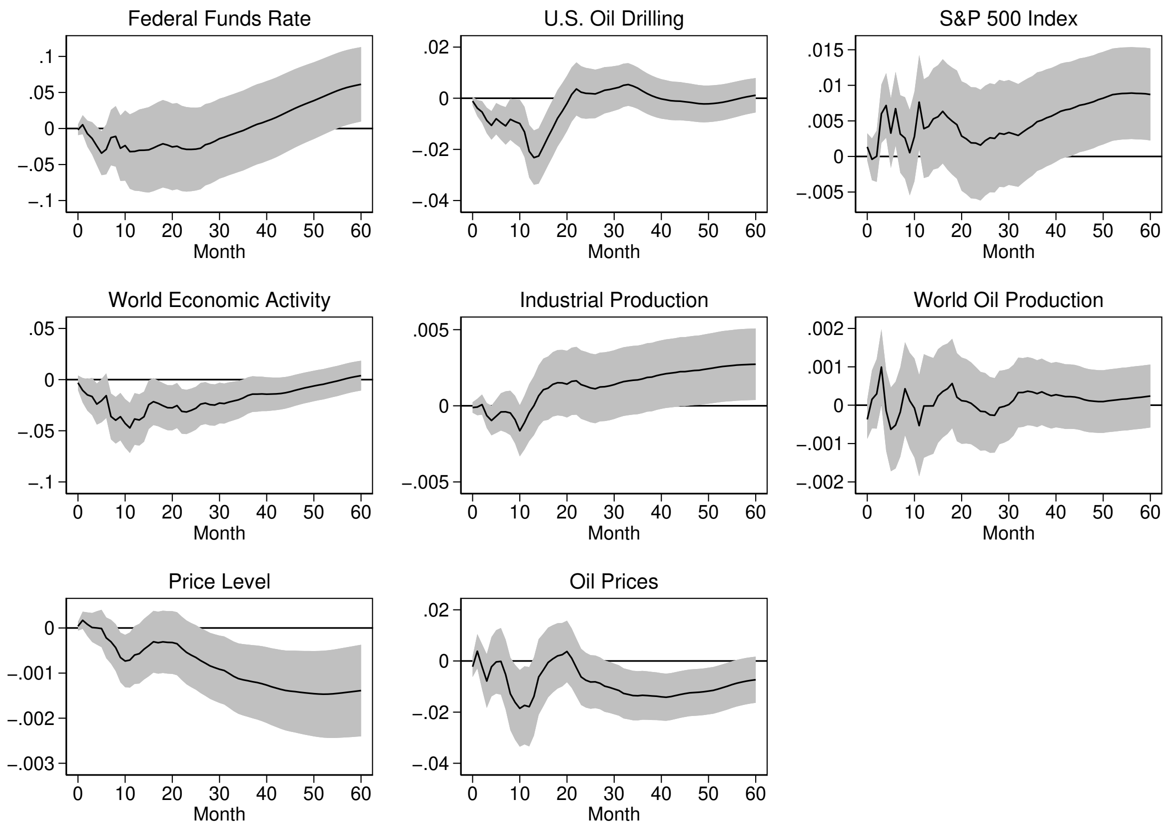


G.3 Controlling for Economic Uncertainty

G.3.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production

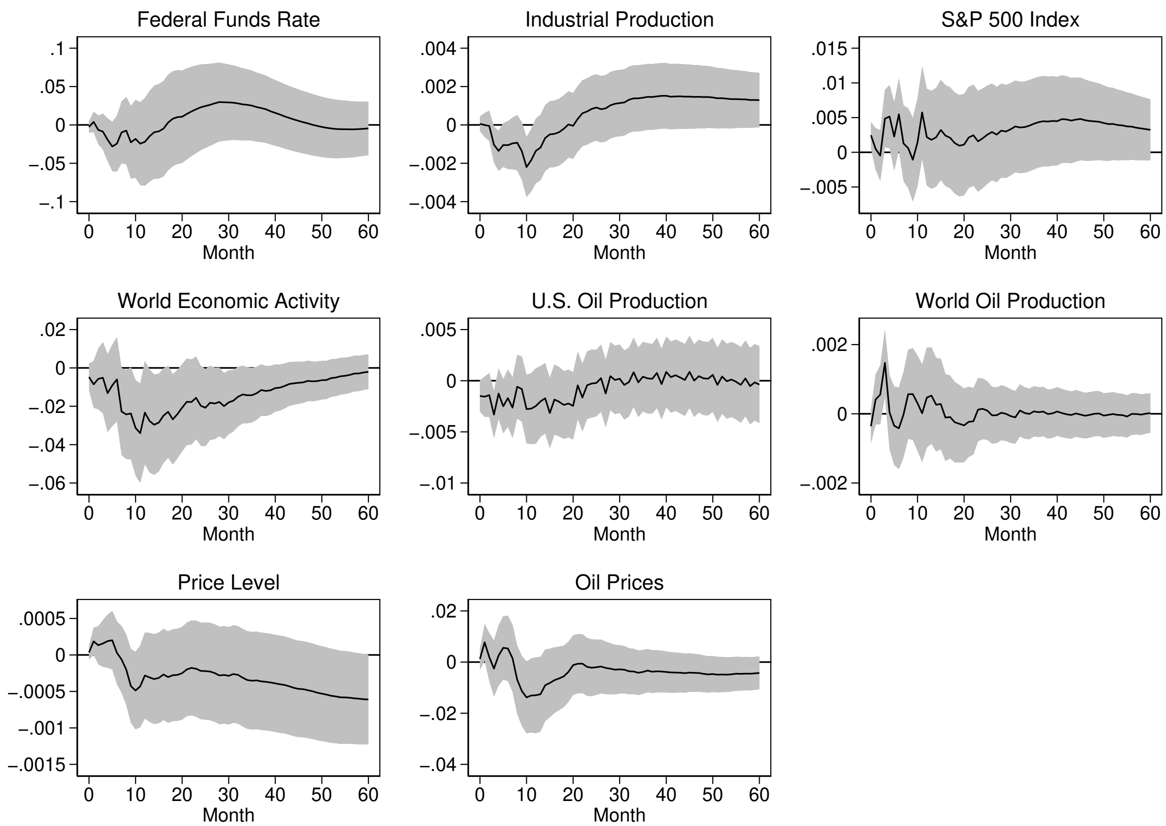


G.3.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling

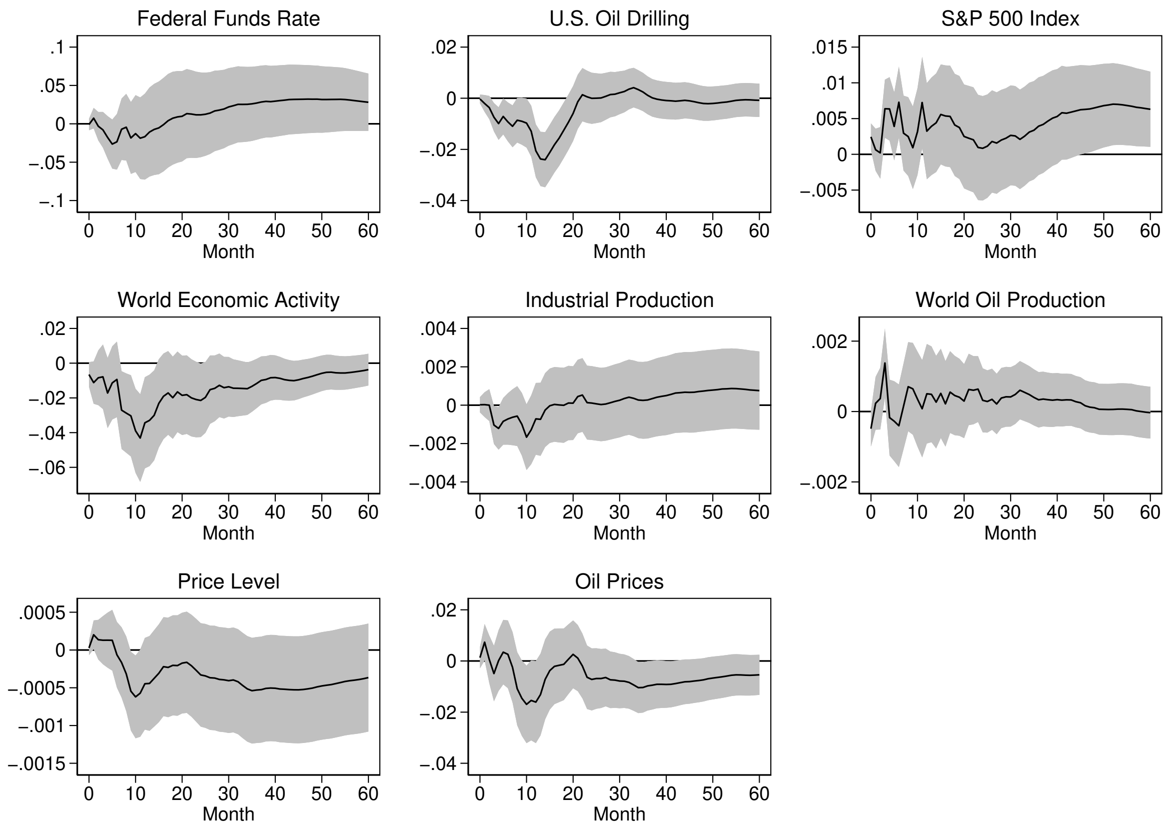


G.4 Controlling for Economic Policy Uncertainty

G.4.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production

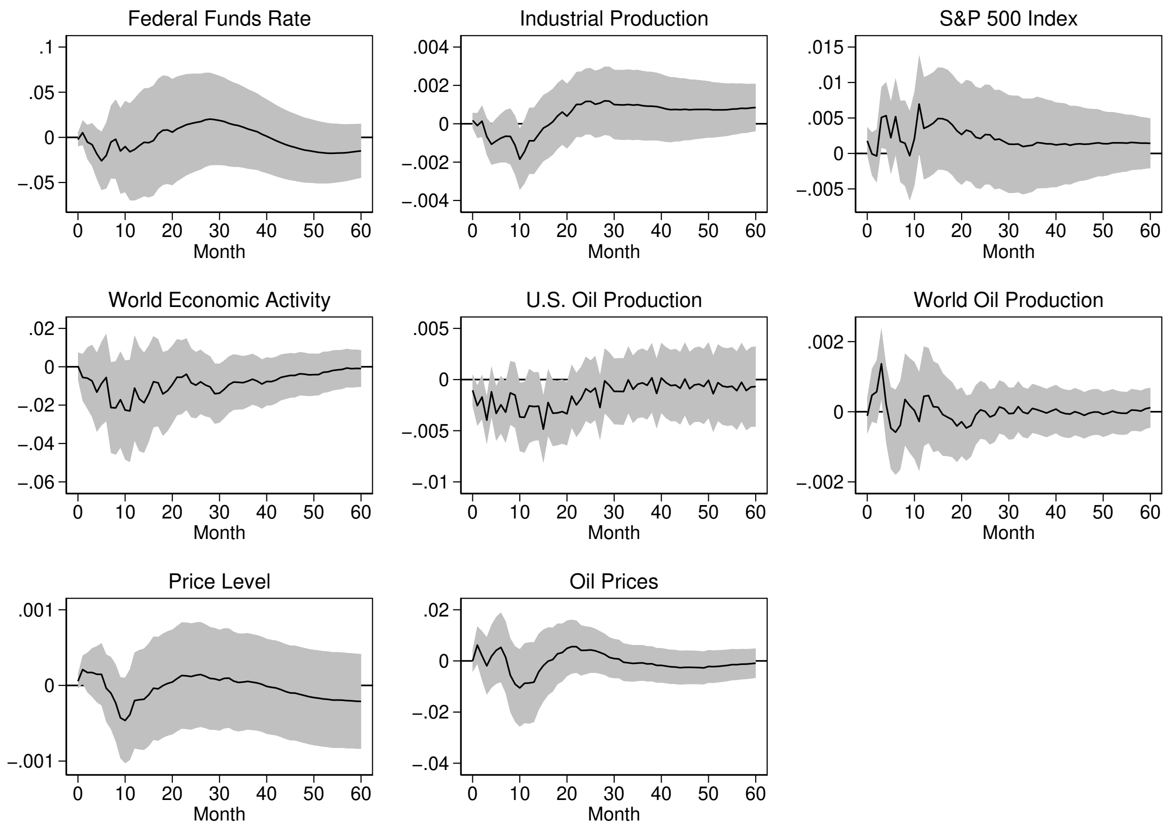


G.4.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling

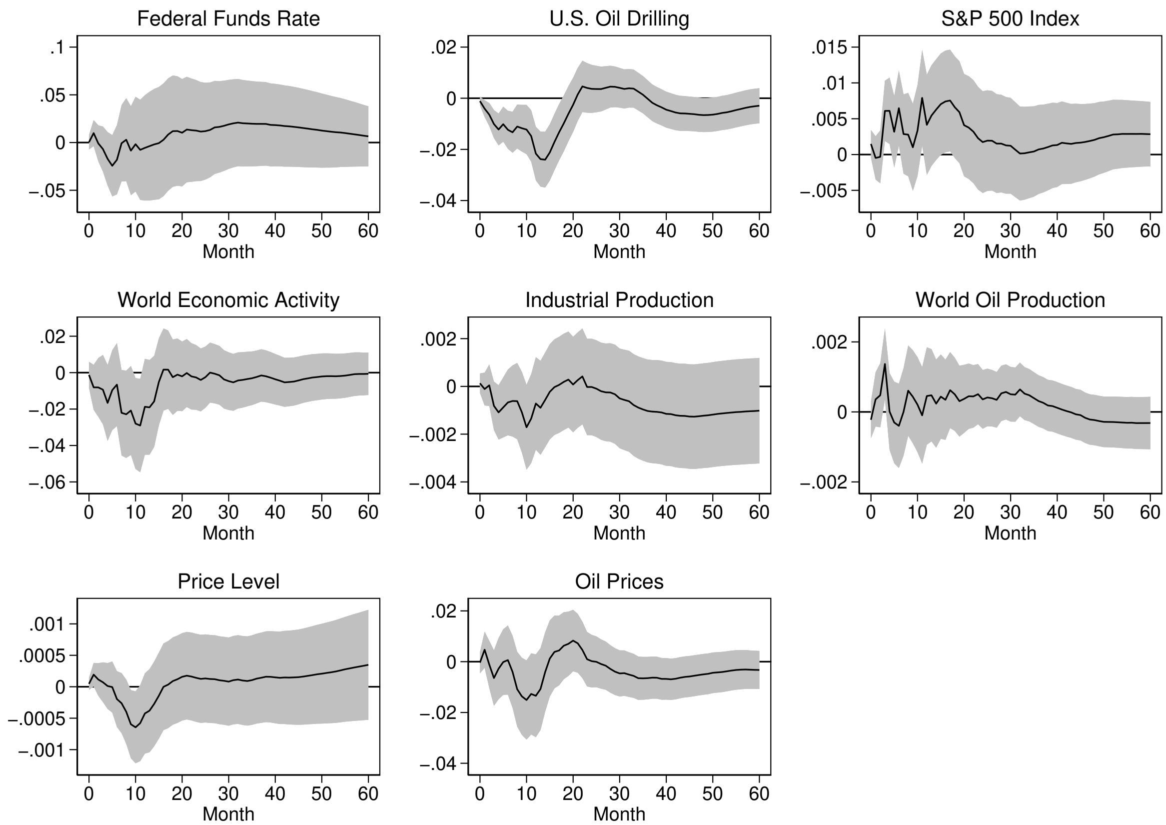


G.5 Controlling for Regulation Category of Economic Policy Uncertainty

G.5.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production

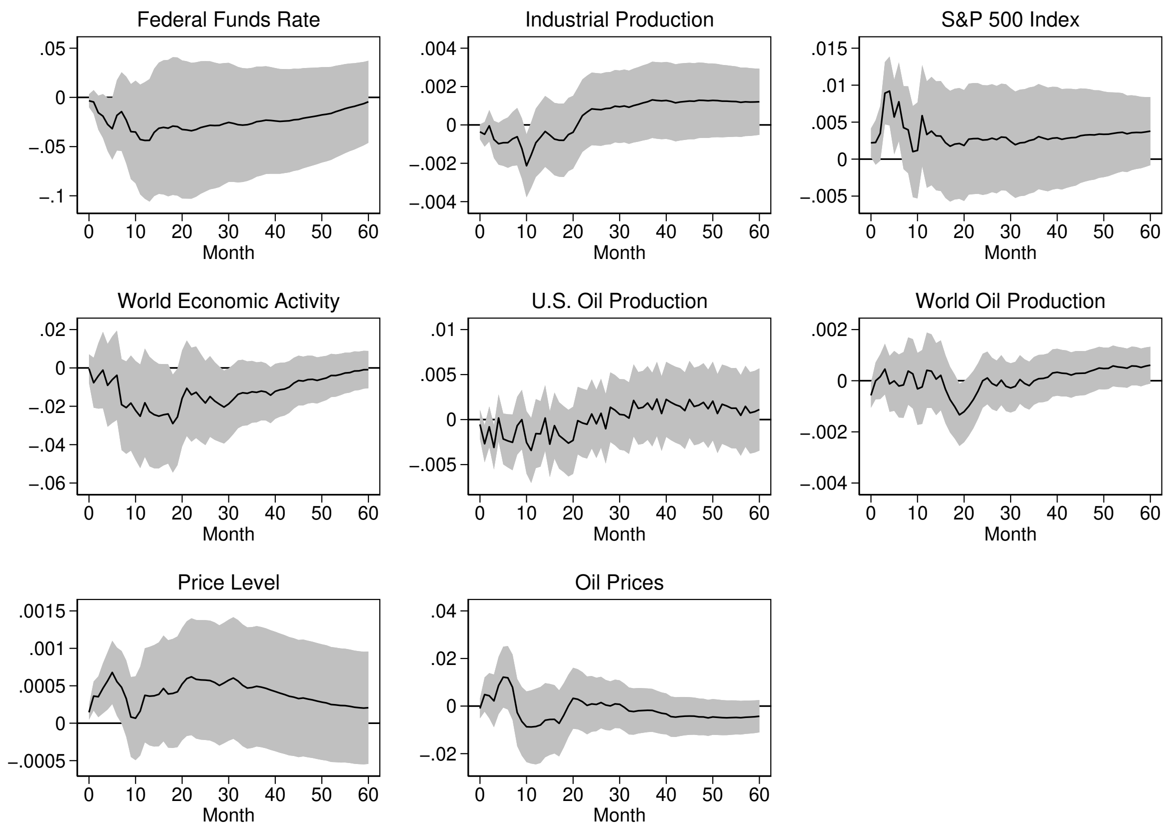


G.5.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling

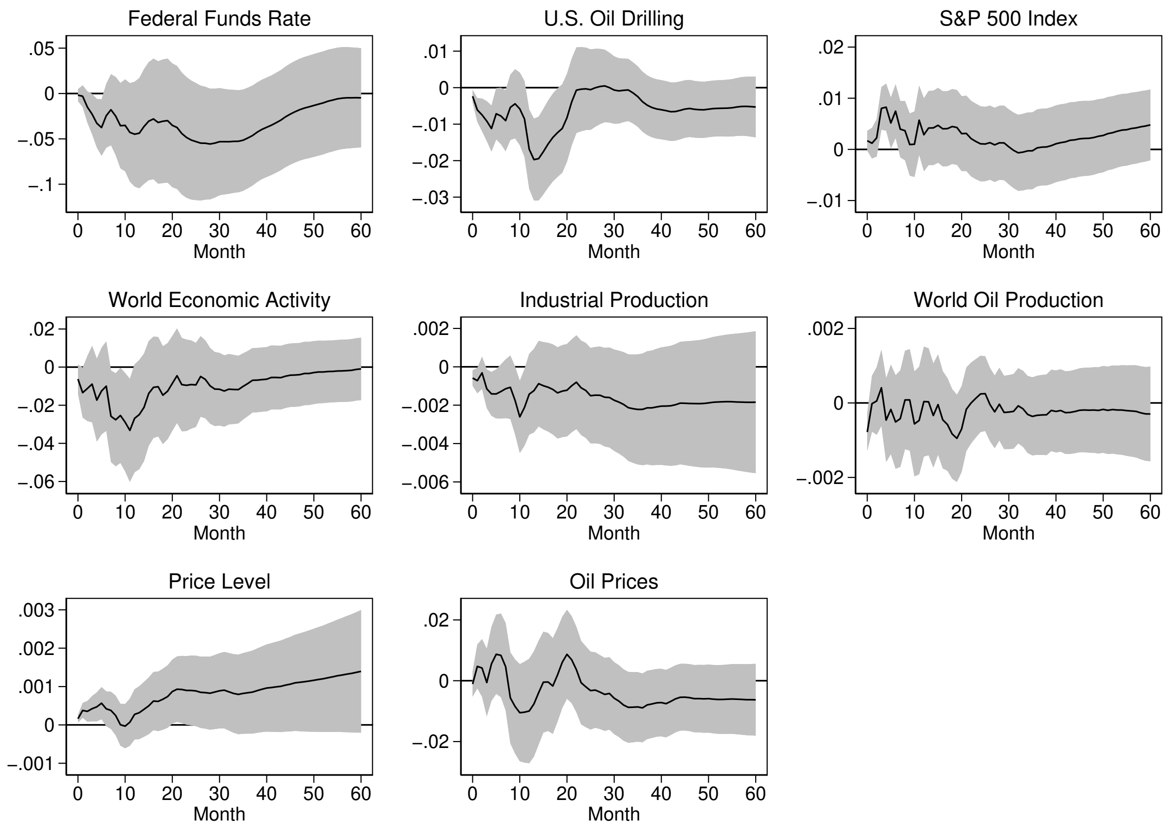


G.6 Controlling for Climate Policy Uncertainty

G.6.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production

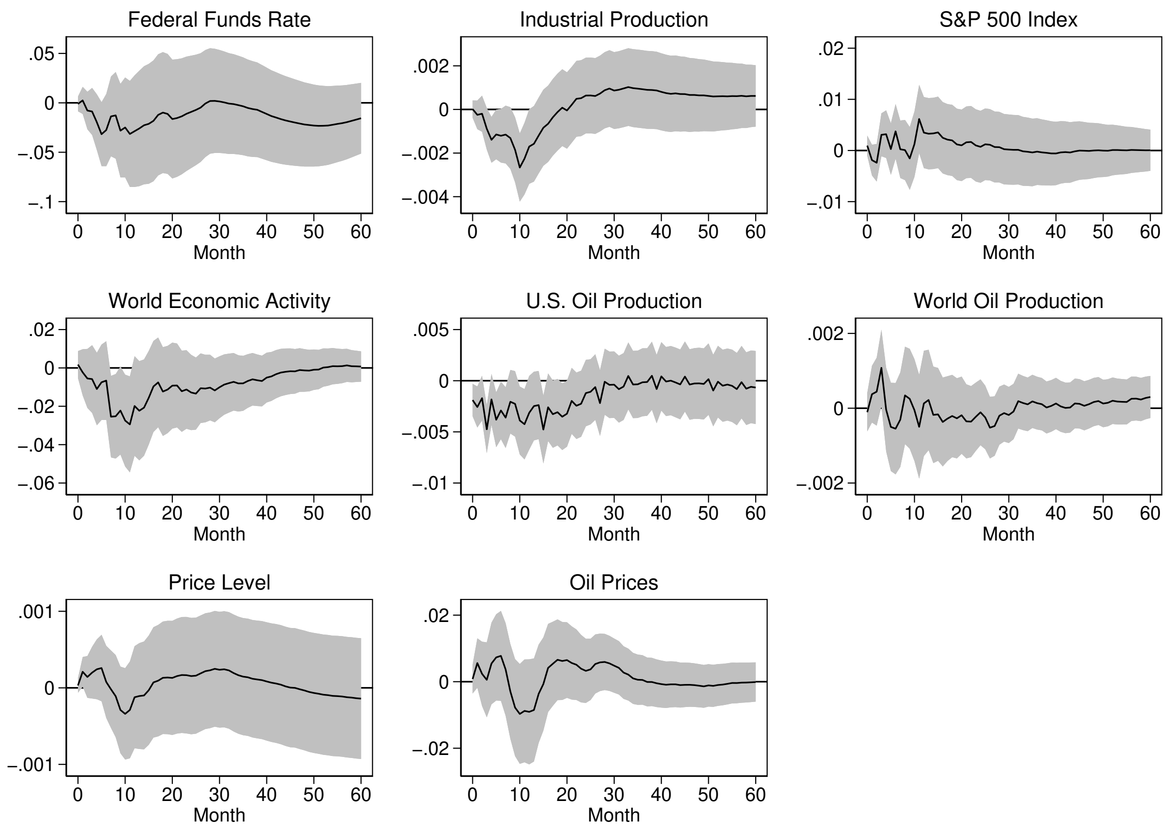


G.6.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling

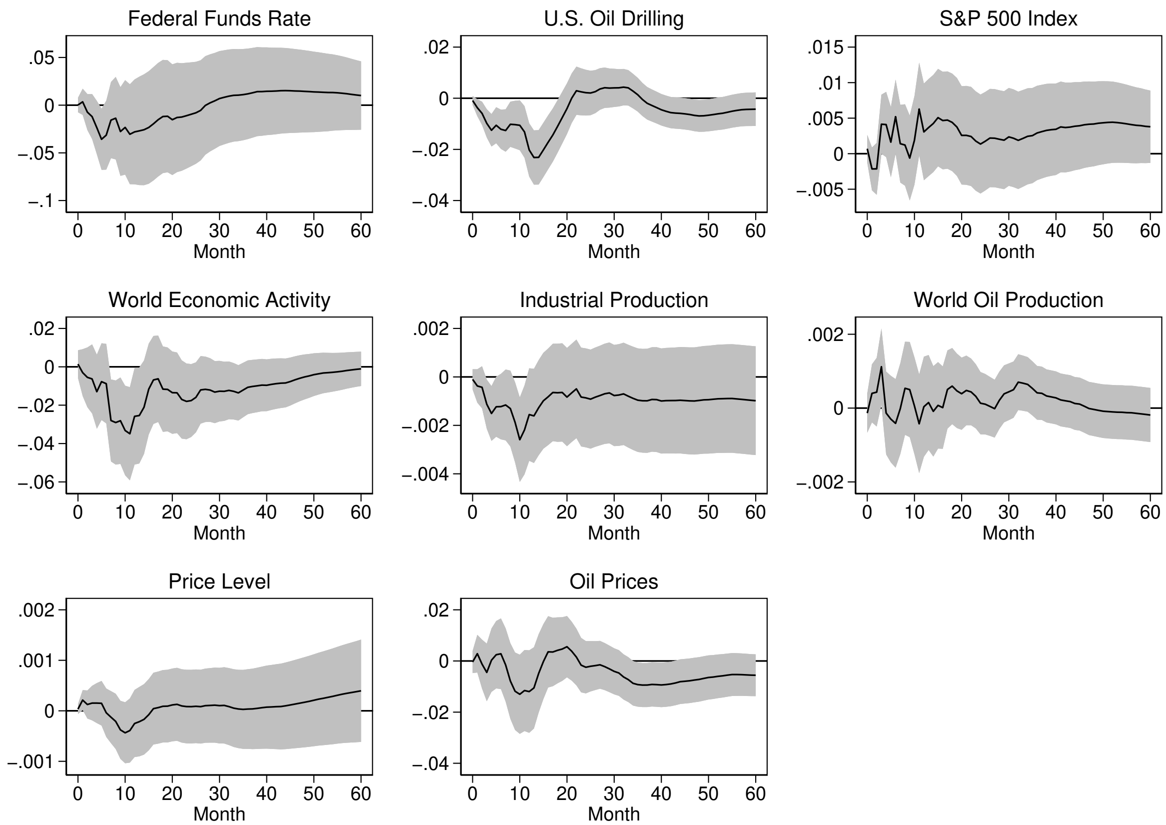


G.7 Controlling for Geopolitical Risk

G.7.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production



G.7.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling



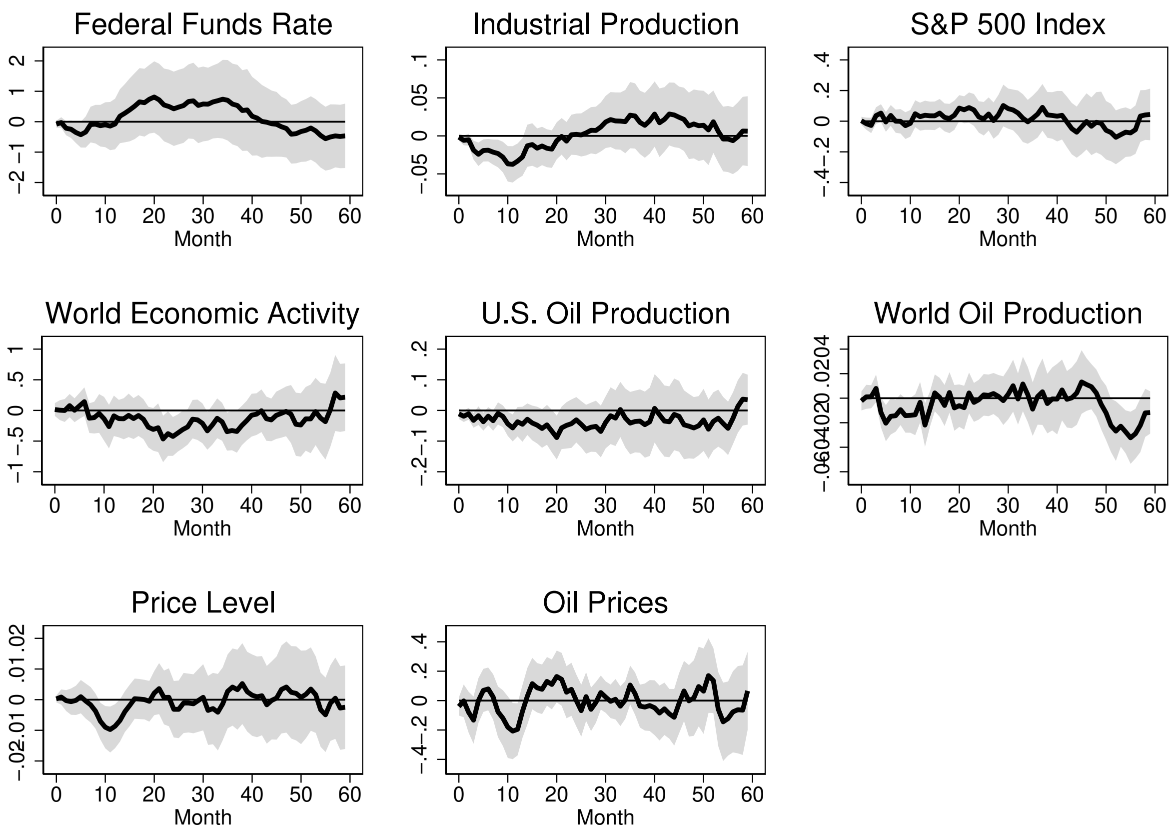
H The Impact of Oil Regulatory Uncertainty Shocks, Estimated on the Local Projection Method

In this robustness check, we estimate the impulse responses of oil production and oil drilling to a oil regulatory uncertainty shock using the local projection method of Jordà (2005). The estimation entails a distinct linear regression for each forecast horizon h with the following specification:

$$y_{i,t+h} = \alpha_i^h + \beta_i^h unc_t + A_i^h \sum_{\tau=1}^{q} X_{t-\tau} + \varepsilon_{i,t+h}, \tag{5}$$

where y_t is one of the economic or oil market variable in matrix X, unc is the oil regulatory uncertainty index constructed in this study, and the matrix X includes lagged values of the dependent variable, our oil regulatory uncertainty index, log S&P 500 index, federal funds rate, log CPI, log U.S. oil production, log industrial production, log world oil production, world economic activity, and log real oil prices. We set $q = 12$ and consider horizons up to 60 months after the shock ($h = 0, 1, ..., 60$). The following figures plot the cumulative responses of oil production and oil drilling to an oil regulatory uncertainty shock.

H.1. The Impact of Oil Regulatory Uncertainty Shocks on Oil Production



H.2. The Impact of Oil Regulatory Uncertainty Shocks on Oil Drilling