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

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Abstract

This paper concerns the economic impact of uncertainty about U.S. regulatory policies of the energy sector. We first use natural language processing to create an oil regulatory uncertainty index based on more than a million news articles from a wide range of U.S. newspapers published between January 1985 and December 2021. We then conduct empirical analysis via structural VAR models with regulatory uncertainty and aggregate data. The impulse response functions suggest that an increase in oil regulatory uncertainty reduces oil production and operations and has significantly negative effects on nationwide and state-level economic outcomes.

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. For example, the energy sector is identified as a critical industry 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 the states that have 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 (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% 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 about regulations of the energy sector.

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. From those articles, we further refine the corpus to cover approximately 133,000 articles that relate to oil and gas production and contain news content discussing regulatory issues. 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 of regulatory uncertainty about oil and gas production (or in short, oil regulatory uncertainty), spanning 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 measures. Using similar approaches, subsequent studies have developed other text-based uncertainty measures concerning trade policy and monetary policy (Caldara et al., 2020; Husted et al., 2019). 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). However, our study focuses specifically on uncertainty about energy regulatory policy, which has not been systematically tracked in the existing literature.

Third, given our focus on oil and gas production, 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 paper concentrates on a different type of oil uncertainty—uncertainty around regulations of oil and gas production. However, we also present a general oil supply uncertainty index by using all the news articles related to oil and gas production in our sample (including the non-regulatory content). This index generates economic dynamics

comparable to other oil uncertainty measures in the literature.

The remainder of this paper is structured as follows. Section 2 describes the newspaper text data used in our study. Section 3 discusses the approach to constructing the oil regulatory uncertainty measure. Section 4 shows the empirical analyses conducted to study how oil regulatory uncertainty affects the oil market and the aggregate economy. Section 5 concludes.

2 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 New York Times, Wall Street Journal, the Washington Post, Los Angeles Times, Chicago Tribune, and Boston Globe. We access to 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 3 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 133,730 articles from 360 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.

3 Measuring Regulatory Uncertainty around Oil and Gas Production

3.1 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) 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 follow Sinclair and Xie (2021) in extracting a "regulatory section" from each article related to oil and gas production. Specifically, a regulatory section is defined as the sentence containing keywords starting with "regulat" or "deregulat" (e.g., "regulation," "regulator," "deregulation") and its neighbor sentences (i.e., a sentence before and after the regulatory sentence). If an article contains multiple sentences containing "regulat" or "deregulat," all the sentences and their neighbor sentences compose the regulatory section of the article. If an article does not mention "regulat" or "deregulat" in its body text, the article is excluded from the analysis for regulatory uncertainty. That further refines the corpus to 133,730 oil and gas related articles with regulatory sections.

[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.

3.2 Quantifying Uncertainty

We assess uncertainty expressed in the regulatory sections related to oil and gas production 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 the regulatory uncertainty score of an article as the proportion of uncertainty words in the regulatory section of the article:

$$UncertaintyScore = \frac{UncertaintyWordCount}{TotalWordCount} * 100.$$

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 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.[5]

Of the 133,730 news articles with relevant regulatory sections, 58,291 articles are associated with positive uncertainty scores. In other words, approximately 44 percent of the

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

articles express certain degrees of regulatory uncertainty around oil and gas production. The mean uncertainty score is 0.52, and the standard deviation is 0.79. Appendix B lists ten regulatory sections with the highest uncertainty scores.

To measure changes in regulatory 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:

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

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

Figure 1 displays the time series of the oil regulatory uncertainty index. The level of uncertainty about regulations of oil and gas production is stationary over time, but with occasional spikes in 1987, early 1990s, 1996, 1998, 2008, and 2020. The figure also shows the 12-month rolling means to illustrate the major patterns of oil regulatory uncertainty over time.

We trace back to news articles to identify historical events or factors that may explain the regulatory uncertainty spikes. One way we use to interpret the relevant news articles is to generate the n-gram word clouds of the regulatory sections published in the months with higher regulatory uncertainty. Figure 2 shows word clouds with the 50 most frequent noun phrases contained in the regulatory sections for each of the six months with the largest spikes.[6] It reveals that the regulatory sections discuss various regulatory issues that may affect the energy sector. For example, "environmental regulation" was discussed extensively in news articles published in early 1990s, coinciding with a boom of pollution controls during

[6]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 (bigrams and trigrams).

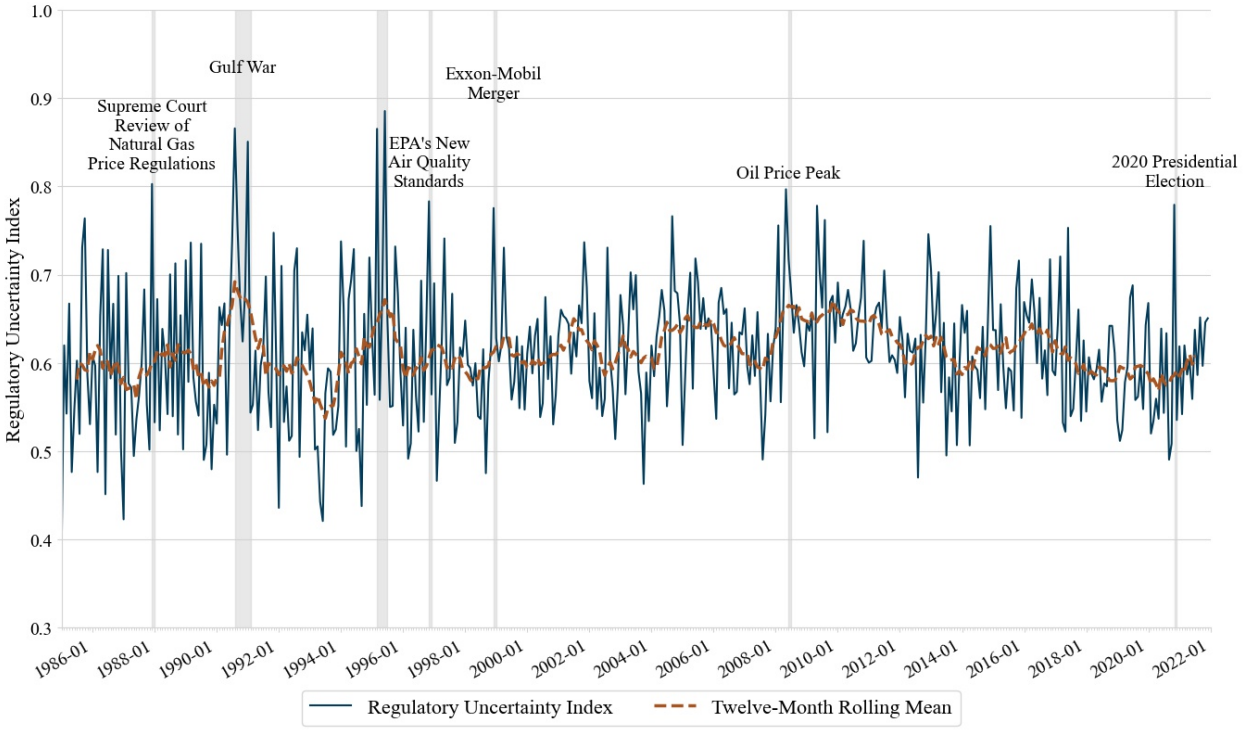

Figure 1: Oil Regulatory Uncertainty Index

that period including federal and state regulations implementing the 1990 Clean Air Act Amendments and Oil Pollution Act. Increased regulatory uncertainty in December 1987 is at least partially related to disputes over the interpretation of the 1978 Natural Gas Policy Act, which developed into a Supreme Court review of a government ruling on natural gas prices. Similar analysis also indicates possible linkages between regulatory uncertainty spikes and the merger of Exxon and Mobil in December 1998 and the presidential election in November 2020.

3.3 Discussion

Using a Broader Set of Energy Terms

To check whether the baseline 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

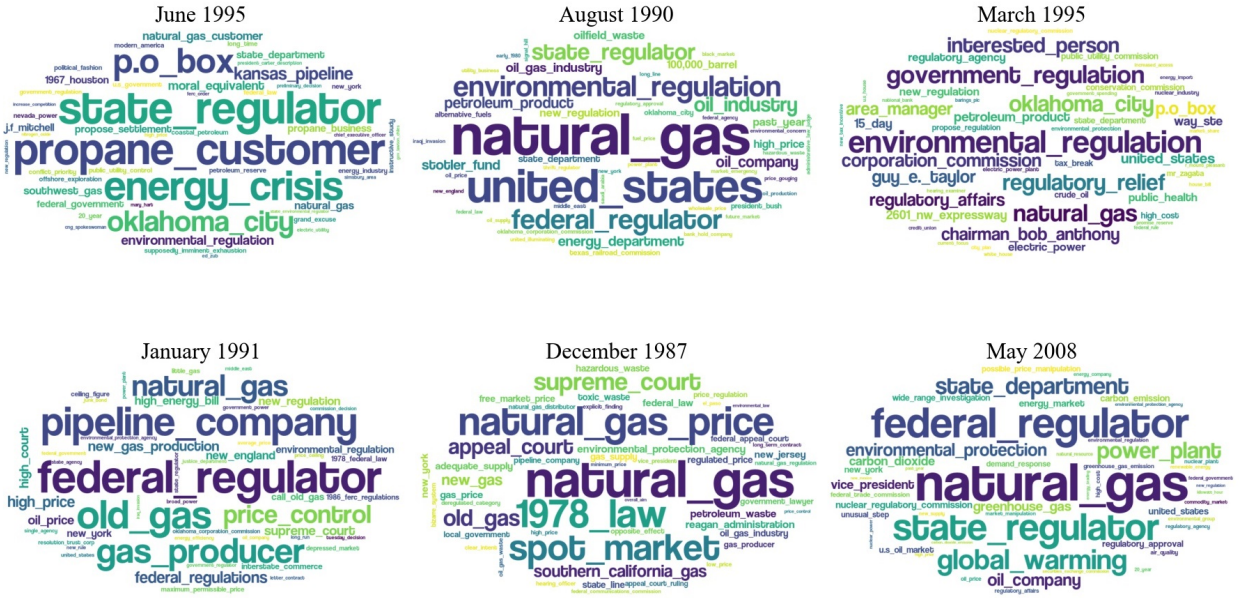

Figure 2: Months with the Largest Oil Regulatory Uncertainty Spikes

U.S. Department of Labor.[7] 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, which contain 140,307 "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 validate our approach of identifying 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,

[7]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.

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 identify relevant articles from the initial corpus. 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 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.

General Oil Supply Uncertainty

To further verify the validity of our oil regulatory uncertainty measure, we construct an index that captures general uncertainty about oil and gas production, namely oil supply uncertainty, using all the 600,953 articles related to oil and gas production as described in Section 3.1. We assess uncertainty expressed in the full text of these articles and construct the time series index using the same regression method as in Section 3.2.

Compared to the regulatory index, the spikes in general oil supply uncertainty coincide with broader (non-regulatory) historical events that can significantly affect oil firms' operational decisions, such as the Gulf War, the Iraq War, and the Coronavirus outbreak. Figure 3 shows the n-gram word clouds of news articles published in the months with substantial oil supply uncertainty spikes. As suggested, the months that have elevated levels of uncertainty are consistent with those suggested in the literature. Additionally, the empirical results in the next section show that the oil supply uncertainty we construct can generate economic dynamics comparable to other oil uncertainty measures in the literature.

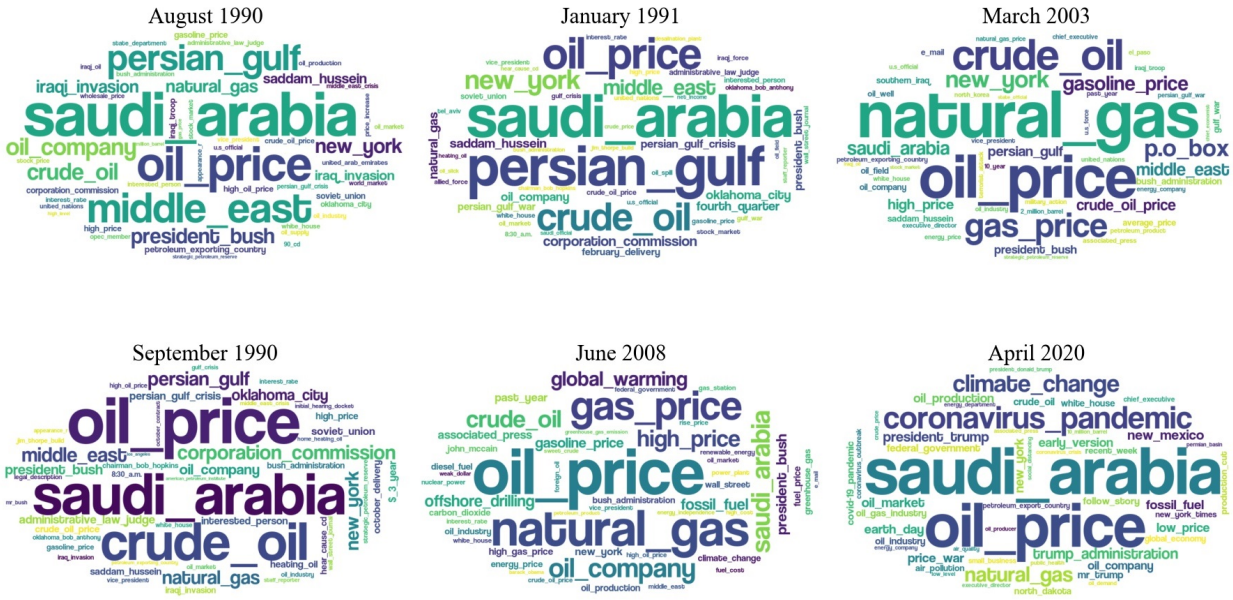

Figure 3: Months with the Largest Oil Supply Uncertainty Spikes

Using Trade Journals and Magazines

One may wonder whether the information extracted from general news media is more likely to reflect public uncertainty on energy-related regulations, instead of the uncertainty experienced and concerned by oil and gas firms. To shed light on that, we use an alternative data source to newspapers, including 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.[8] 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.

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, whereas the 12-month rolling means of the indices have a statistically significant, moderate correlation of 0.40. The variations between the alternative and base-

[8]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.

line indices may indicate that firms perceive regulatory changes differently than the public. However, it may also be a result of the limitation of the data. Unlike newspapers, the 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.

Although the alternative index is only moderately correlated with our baseline index, using this index does not change the major conclusions we draw from the empirical analysis in the next section. Empirical exercises based on this index are shown in Appendix C.

4 Empirical Analysis

4.1 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, as well as economic activities. The baseline model 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. To recover the orthogonal shocks to regulatory uncertainty

about oil and gas production, we use recursiveness identification with the following ordering:

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

The baseline model is estimated on monthly data for the periods between 1985m1 and 2021m12. We define a regulatory uncertainty shock as the first innovation in the structural VAR, which means that changes in regulatory uncertainty about the energy sector are able to affect the financial market and the real economy contemporaneously. 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 VAR includes 12 lags of all variables.

4.2 Estimation Results

General Oil Supply Uncertainty

First, to illustrate the impact of the general oil supply uncertainty constructed from our textual approach, we estimate a structural VAR model with the same variables as the baseline model, except that oil regulatory uncertainty is replaced by the general oil supply uncertainty index constructed by the approach introduced in Section 3.3. The impulse responses are displayed in Figure 4. For this figure and other impulse response figures, solid lines plot the

point estimates, and gray areas plot the 68% (+/- one standard error) confidence interval, which is constructed using a bootstrap with 2,000 replications. Similar with the literature as in Elder and Serletis (2010), Jo (2014) and Ma and Samaniego (2020), an increase in oil supply uncertainty depresses world oil production as well as economic activities. The central bank lowers the policy rate to stimulate the economy.

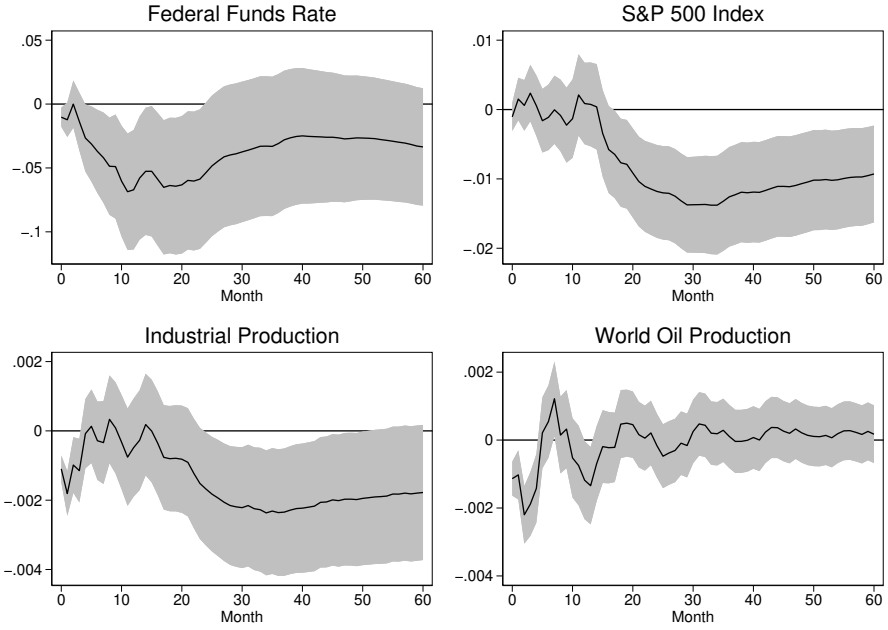

Figure 4: The Impact of Oil Supply Uncertainty Shocks

Oil Regulatory Uncertainty

Next, Figure 5 shows the impulse responses to uncertainty shocks to U.S. regulations of oil and gas production. We find that an increase in oil regulatory uncertainty reduces U.S. oil production mainly in the short run. 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, as both industrial production and world economic activity decline. Compared to the macroeconomic impact of oil supply uncertainty, however, the influence of oil regulatory uncertainty is less significant.

Results are similar when we estimate VAR models by ordering regulatory uncertainty as the last variable, using stationary detrended variables, or adding aggregate economic uncertainty as an additional variable.

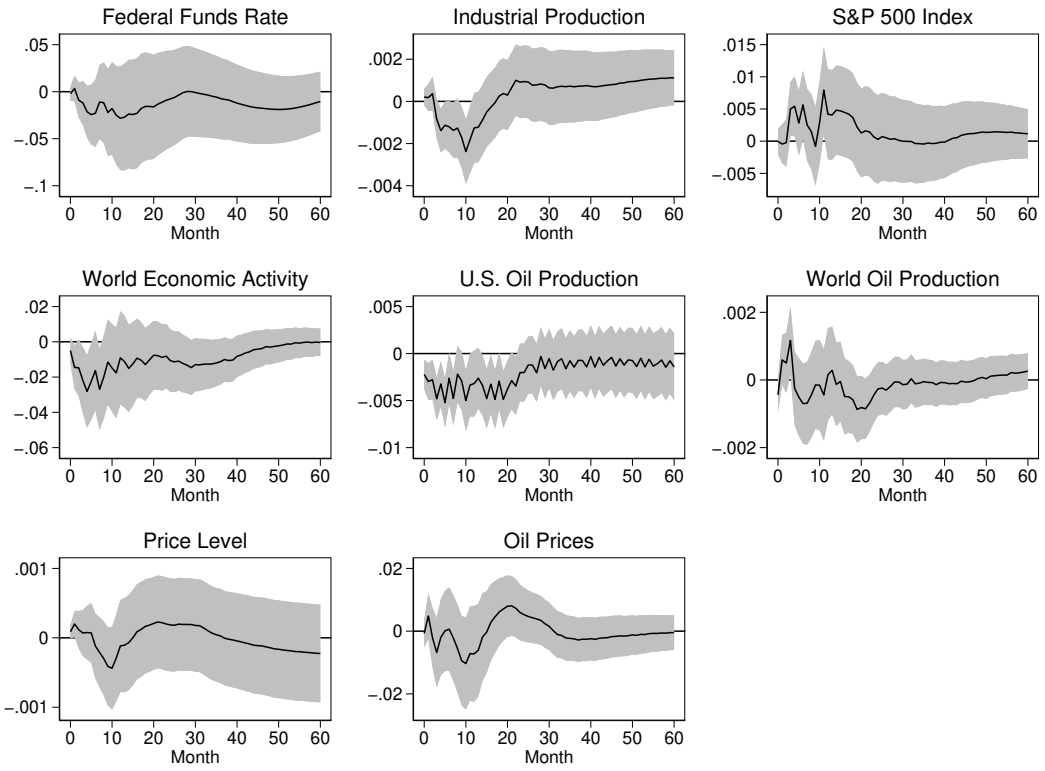

Figure 5: The Impact of Oil Regulatory Uncertainty Shocks, with Oil Production

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 also affect oil and gas producers' longer-term plans, which can in turn affect oil and gas drilling contracts and operations. To investigate 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 significantly negative effects on U.S. oil drilling 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

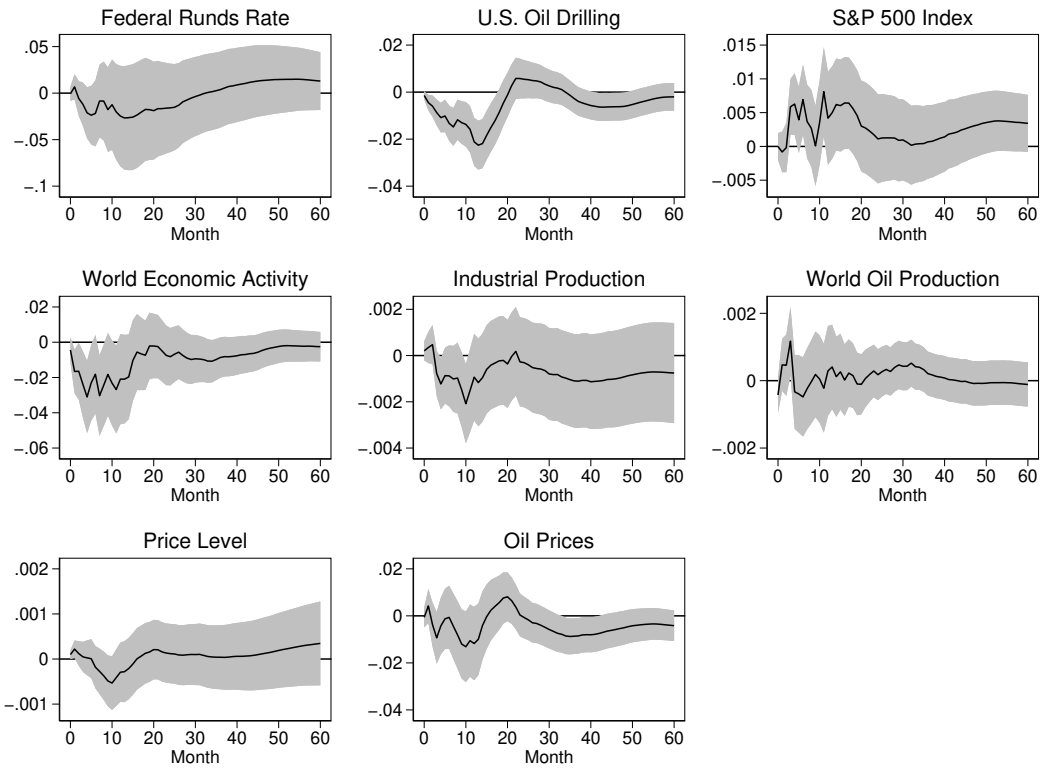

Figure 6: The Impact of Oil Regulatory Uncertainty Shocks, with Oil Drilling

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 weaker compared to Figure 5 where oil production is included in the model. Our results are robust when estimated on the local projection method, which are shown in Appendix D.

Another interesting question is whether the impact of oil regulatory uncertainty on oil production and oil drilling is different when different political parties are in the government. To address this question, we introduce to the local projection regressions an interaction term between the oil regulatory uncertainty index and a dummy variable, which equals to 1 when the U.S. president is a Republican and 0 for a Democrat. Figure 7 shows the estimated coefficient of this interaction term, i.e., the difference in responses of oil production/oil drilling to an increase in oil regulatory uncertainty under a Republican or Democratic president.

The differences are almost always insignificant for oil production. Oil drilling is less negatively affected by increased uncertainty under a Republican president in the very short run, as shown by the significantly positive response during the first few months after the shock. This is consistent with the fact that a Republican government is generally considered more business-friendly and tends to impose less strict regulations on oil companies than a Democratic government.

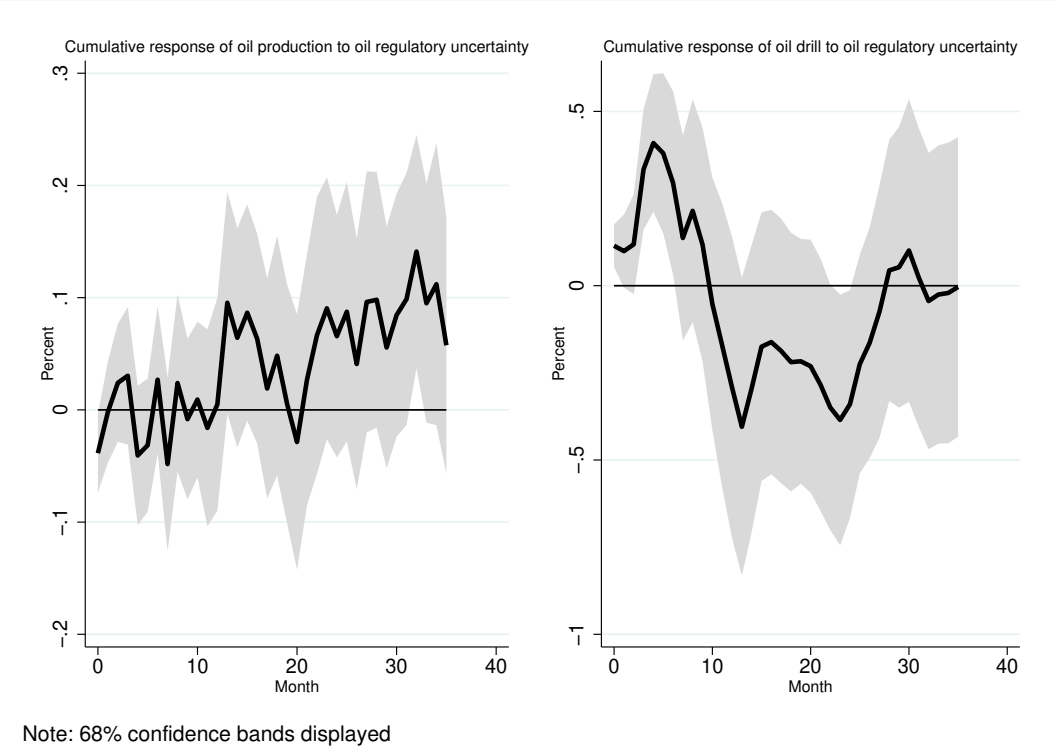

Figure 7: The Difference in the Impact of Oil Regulatory Uncertainty Shocks under Different Political Parties

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 using the local projection method 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 persistently affected by an increase in oil regulatory uncertainty. This finding is not surprising, as oil and gas production is more dominant in Texas and New Mexico than the other states considered in this exercise.

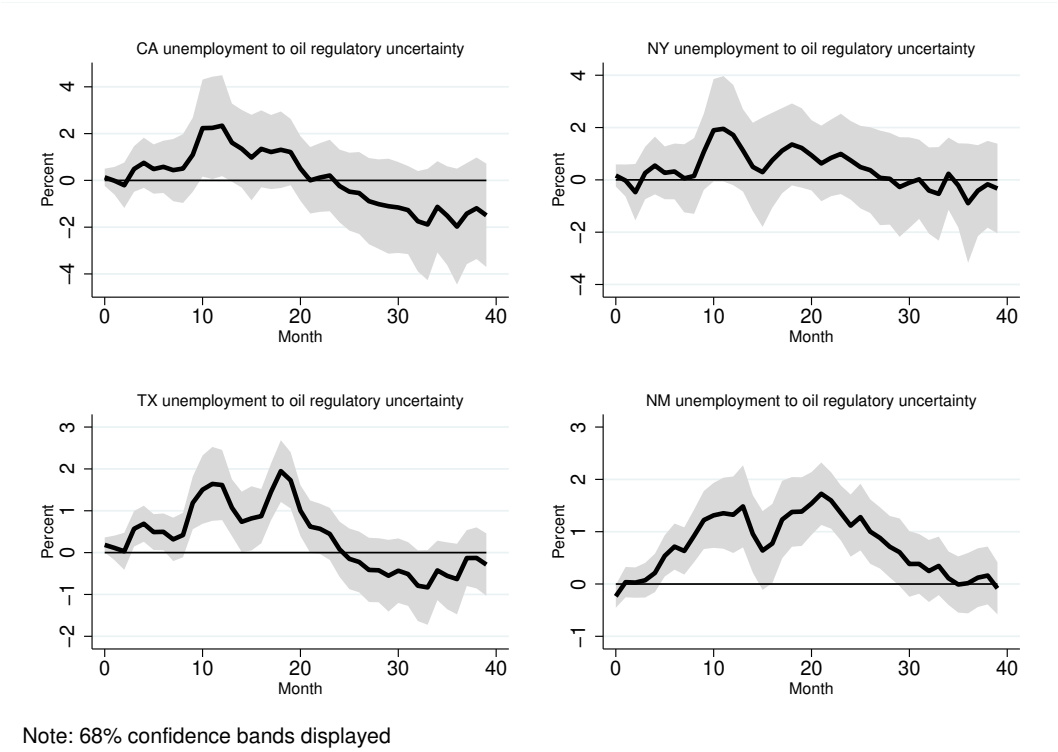

Figure 8: The Impact of Oil Regulatory Uncertainty Shocks on Various States

5 Conclusion Remarks

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 impacts of increased oil regulatory un-

certainty. 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 using the local projection method. Moreover, the negative impact of oil regulatory uncertainty on oil drilling is more prominent under a Democratic president than a Republican, 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.

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"

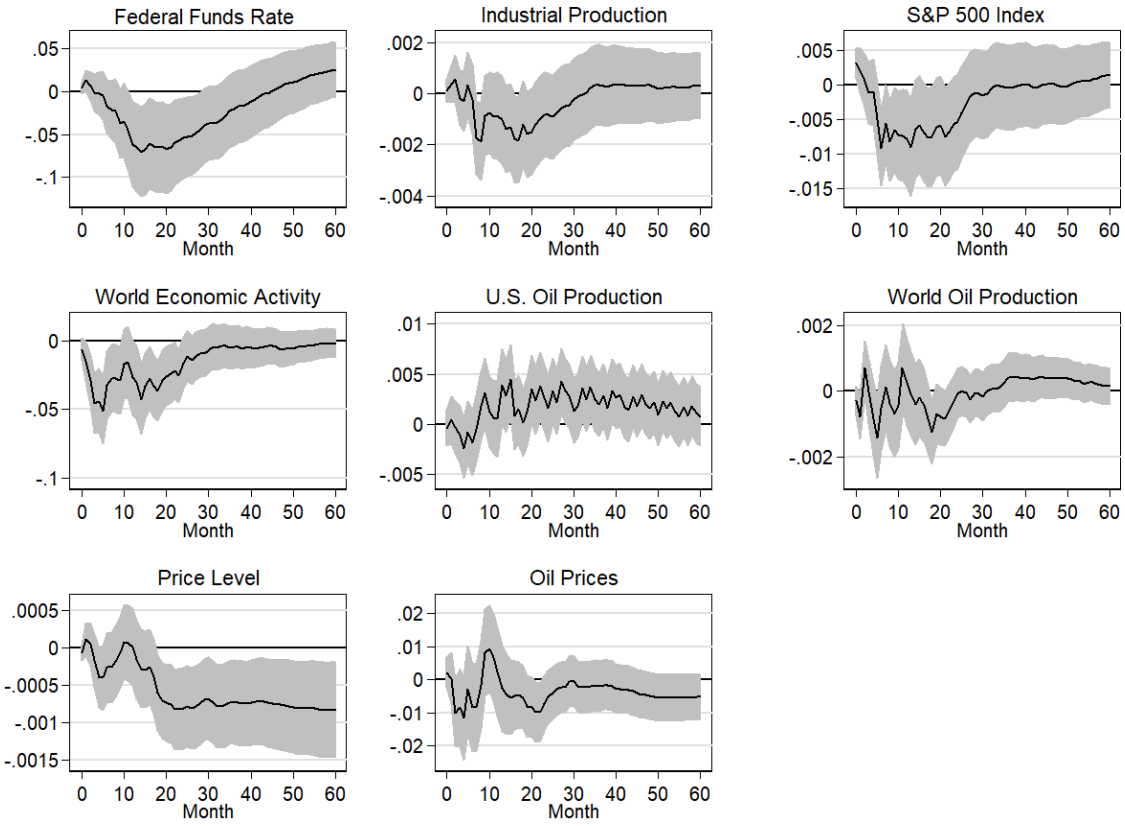
B Articles with the Highest Regulatory Uncertainty Scores

Article Title	*Newspaper*	*Publication Date*	*Regulatory Section*
Gov. Kasich wants top income tax to be under 5%	The Blade	3/10/2014	Surplus. Regulatory predictability. Lower cost of doing business.
Problems and Pepco's Power Needs	The Washington Post	4/2/1990	Who's willing to take the risk? Regulators? Environmentalists?
Personal Touch Eliminates Excess Torque	Chicago Tribune	4/6/1997	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.
Recycling: It's the right thing to do	Times News	8/18/2011	Bauxite and petroleum may not be mined domestically. Other countries may not have the same environmental regulations that we have. Recycling can create jobs.
Obama's climate hubris	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.
Grass Symposium, Exhibit Get To The Root Of Civilization	Chicago Tribune	7/11/1986	Even animals, such as the giant panda in China, depend heavily on it as a source of food. Through his research, Soderstrom has found that the flowering cycles are predictable, probably regulated by an as-yet-unidentified biological clock. When various species do flower and die, hardship may result.

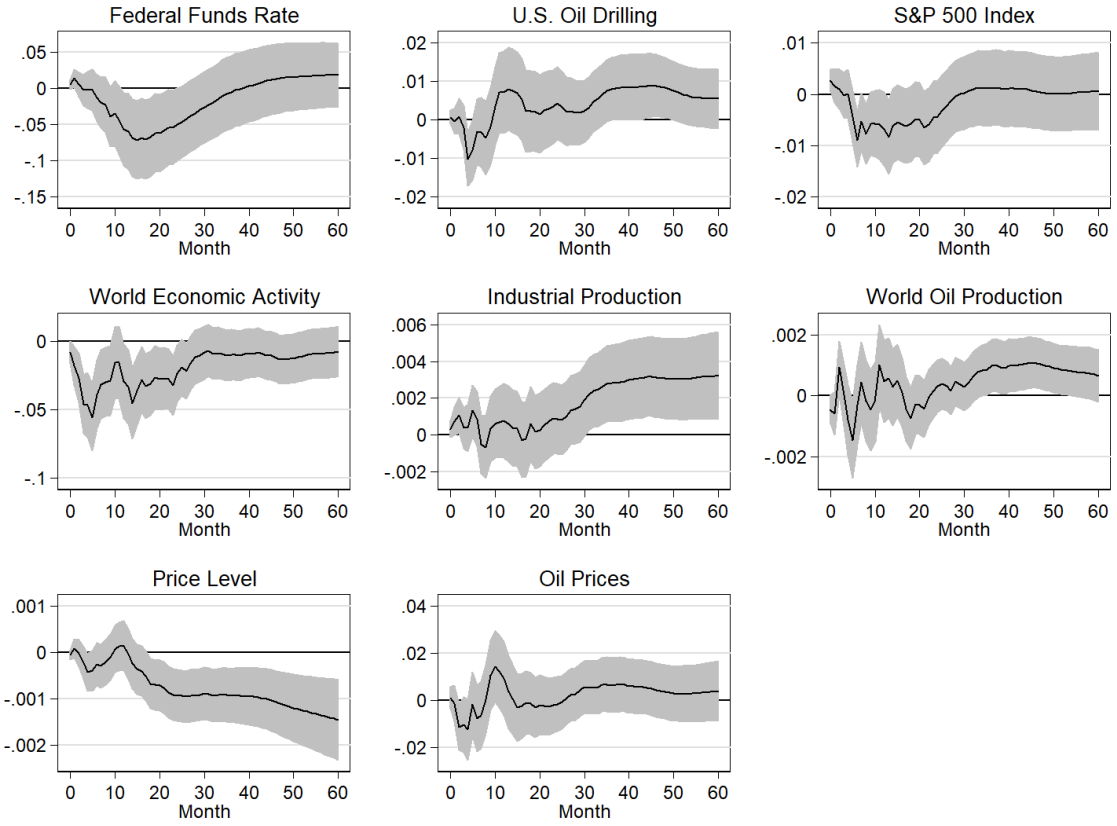
Obama's climate hubris	Sentinel & Enterprise	8/9/2015	The same could be said for the plan announced last week. Defenders of the new regulation predict falling energy costs from renewable sources, but so far, that is pie-in-the-sky speculation. Like the president's prediction that the average family would save $2,500 because of Obamacare.
Ready to catch wave energy's power	The Register - Guard	8/11/2007	And it remains unclear how much input the state could have when it comes to wave energy. 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. But any comprehensive plan may be tough to fashion, given the confusion about who's really in charge.
2 councilmen get fired up over gas at Thermal	Nashville Banner	1/3/1997	The possibility of a second upgrade in 2009. The EPA is said to be already working on the new regulations. The possibility the city could lose its ability to require haulers to take their garbage to the thermal plant.
Nation	St. Louis Post - Dispatch	8/25/2000	Currency may be confiscated from those who don't. 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. 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.

C The Impact of Oil Regulatory Uncertainty Shocks, Using Trade Journals and Magazines

C.1 The Impact of Oil Regulatory Uncertainty Shocks, with Oil Production



C.2 The Impact of Oil Regulatory Uncertainty Shocks, with Oil Drilling

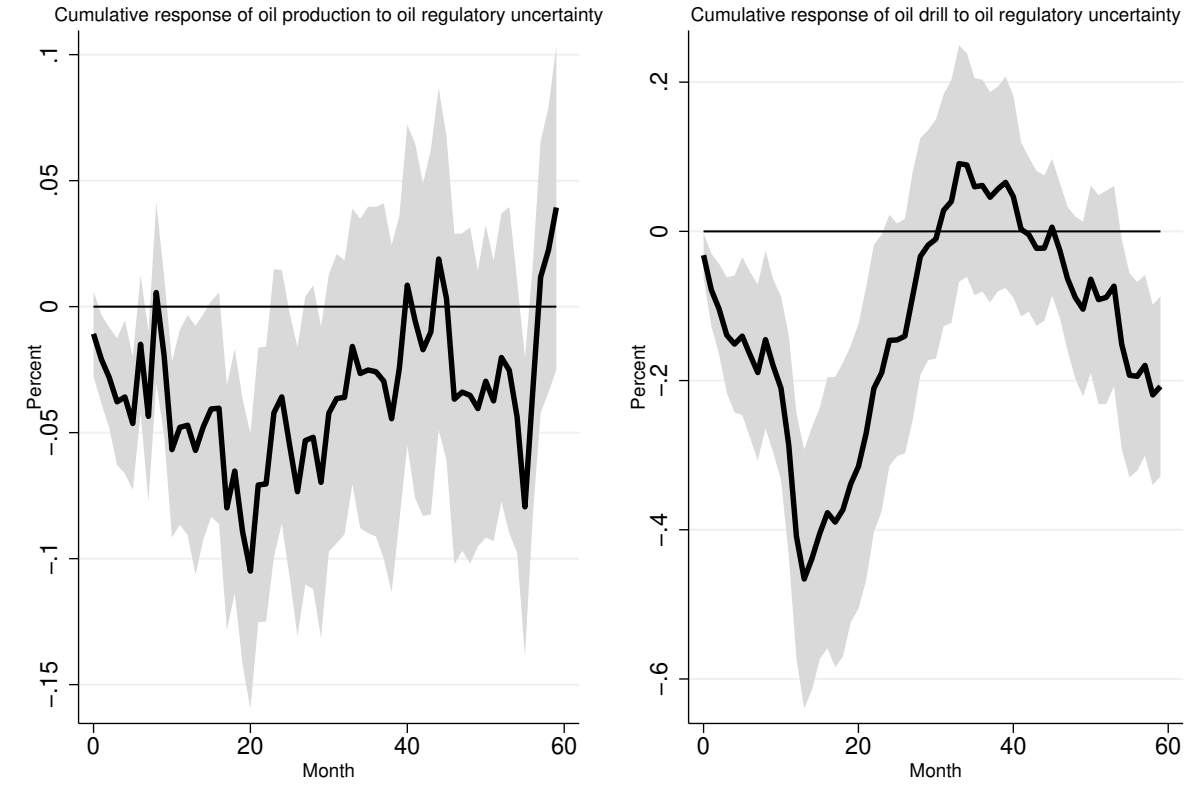


D The Impact of Oil Regulatory Uncertainty Shocks, Estimated on the Local Projection Method

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:

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

where y_t is log U.S. oil production (or log U.S. oil drilling), 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 world oil production, word 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 figure plots the cumulative responses of oil production and oil drilling to a oil regulatory uncertainty shock.



Note: 68% confidence bands displayed