The Political Economic Effects of Chernobyl on U.S. Nuclear Power (Preliminary)*

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Abstract

This paper documents that following the Chernobyl accident: (i) U.S. fossil fuel firms significantly increased their campaign contributions; (ii) Members of Congress who received contributions from fossil fuel firms or represented states economically reliant on fossil fuels became more likely to vote against nuclear energy; and (iii) newspapers with a higher share of fossil fuel–related advertising revenue published more anti-nuclear articles. These findings suggest that Chernobyl created an opportunity for anti-nuclear interests to lobby against nuclear energy. We provide complementary evidence from the United Kingdom, where Members of Parliament sponsored by miners' unions were much more likely to deliver anti-nuclear speeches after Chernobyl. Back-of-the-envelope calculations indicate that, the post-Chernobyl stagnation in nuclear energy is associated with both heightened ambient pollution — contributing to the loss of approximately 141 million expected life years in the U.S.— and substantially greater exposure to nuclear risks.

Keywords: Energy Investment, Special Interest Group Capture, Sustainability

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"Oil would be worth a lot less if more of the world's energy needs were provided by atomic fission" – Rod Adams, Engdahl, F. William (2012) *A Century of War: Anglo-American Oil Politics and the New World Orders.*

1 Introduction

In the post World War II era, nuclear energy was viewed as the solution to rapidly expanding energy needs. It is reliable and produces minimal pollution.[1] Nuclear power does not rely on fossil fuels, which means that nuclear power plants (NPPs) can be built in countries with little fossil fuel reserves and the global economy need not rely on OPEC countries. The United States was the world leader in the development of nuclear energy and the construction of NPPs. Efforts by the fossil fuel industry, which was directly threatened by the expansion of nuclear, had little effect in the face of enthusiasm from the public, environmentalists and policymakers. In the 1960s, the Atomic Energy Commission projected that by 2000, the U.S. would have over 1,000 operating reactors.[2] However, reality has fallen far short of the optimistic anticipations. In 2024, there are only 94 reactors in 54 NPPs in the U.S..

This paper investigates the role of fossil fuel special interest groups in the decline of U.S. nuclear energy growth. We hypothesize that the fossil fuel industry took advantage of public safety concerns triggered by the Chernobyl reactor meltdown in April, 1986, to campaign against nuclear energy. The U.S. political system is susceptible to lobbying efforts by special interest groups (Grossman and Helpman, 2001). We use a large body of empirical evidence to examine whether fossil fuel interests strategically lobbied against nuclear energy in the aftermath of Chernobyl, and whether their efforts influenced the actions of policymakers.

Our paper proceeds in several steps. First, we establish that the meltdown was widely known in the U.S. and triggered public safety concerns. We document that discussions of the Chernobyl disaster and nuclear safety spiked in major U.S. newspapers immediately after meltdown.

Second, we investigate how fossil fuel lobbying efforts reacted to Chernobyl and public anxiety about nuclear safety. This depends on whether lobbying efforts and public safety concerns are complements or substitutes in policymakers' support for nuclear energy. On the one hand, heightened public concerns about nuclear power might reduce the need for additional lobbying. On the other hand, those concerns can increase the returns to lobbying and prompt the fossil fuel industry to capitalize on public fear. For

[1] The primary source of potential pollution from nuclear energy is the disposal of spent fuel rods, a challenge that can be mitigated by emerging technologies (discussed in the Background section).

[2] See Seaborg, Glenn T., *The Plutonium Economy of the Future*, October 5, 1970, p. 7.

this analysis, we construct a panel dataset on campaign contributions from Fortune 500 companies to members of the U.S. House of Representatives and Senate from 1979 to 1996. We are able to identify whether the company is related to the energy sector, and within the energy sector, whether it is related to fossil fuels. We find that relative to non-energy firms, fossil fuel companies permanently increased their campaign contributions after Chernobyl.

Third, we examine the relationship between campaign contributions and congressional voting, and allow the relationship to differ after Chernobyl. If Chernobyl increased the returns to campaign contributions by reducing policymakers' support for nuclear energy, then we should find that contributions reduced support for nuclear energy more after Chernobyl. For this analysis, we construct a dataset on nuclear-related bills and manually code bill-specific features such as whether each bill was "anti-nuclear" or "high-stakes". We find that, prior to Chernobyl, fossil fuel campaign contributions did not boost anti-nuclear votes or lower pro-nuclear ones. After Chernobyl, however, fossil fuel contributions substantially increased anti-nuclear votes and reduced pro-nuclear votes. These effects are particularly pronounced for bills that passed by narrow margins.

The results for campaign contributions and voting together imply that fossil fuel companies raised their contributions after Chernobyl, which shift policy towards being more anti-nuclear. They are consistent with the view that public safety concerns and campaign contributions are complements and that the fossil fuel industry capitalized on the former in lobbying against nuclear energy.

Fourth, we consider the fact that voters' economic interests align with those of fossil fuel industries if they depend on the industry for employment. Elected officials who represent constituencies with greater economic reliance on the fossil fuel industry will be more motivated to preserve the sector and reduce nuclear expansion. They may also view Chernobyl as an opportunity to make meaningful push against nuclear investment. Consistent with this hypothesis, we find that elected officials in states with a higher share of GDP from fossil fuel industries are more likely to vote against nuclear energy after Chernobyl. Interestingly, the fossil fuel share of a state's GDP has no effect on campaign donations. which is consistent with the view that constituent concerns are important in driving voting behavior after Chernobyl.

Fifth, we consider the possibility that the fossil fuel can attempt to directly shape voter opinion by influencing news coverage. We investigate whether fossil fuel advertisement revenues in newspapers change after Chernobyl, and whether they affect news coverage of Chernobyl. We construct a dataset of news articles and advertisements in historical newspapers for the six months before and the six months

after the Chernobyl accident. To measure advertisements, we apply a deep-learning OCR model that is fine-tuned to identify newspaper layouts and convert graphical newspaper copies into textual data. This time horizon is shorter than in the campaign and voting analysis because news outlets focus on current events and move on to other topics relatively quickly. We find that newspapers with higher advertisement revenues from fossil fuel companies prior to Chernobyl published more anti-nuclear articles in the weeks after the accident. This is consistent with fossil fuel advertisements influencing news coverage, and also with the possibility that editorial preferences in newspapers with higher fossil fuel advertisement revenues have are aligned with the fossil fuel industry. We do not observe a change in fossil fuel advertisement spending after the accident, which could be explained by the time-sensitive nature of news coverage, making it difficult for fossil fuel companies to leverage short-term advertisement buys on a quid pro quo basis.

The main analyses using U.S. data provide strong evidence that the negative shift in nuclear policy is partly driven by lobbying efforts from the fossil fuel industry and may also reflect fossil fuel–based economic interests of voters.

In the remainder of the paper, we supplement the main analysis by examining several questions for which we will be unable to provide conclusive answers, but which are important for understanding the significance of our findings and guiding future research. One question is whether the U.S. is unique in the stark decline in NPP after Chernobyl and the fact that the decline is partly driven by political economic motives. To shed light on this question, we examine data from the United Kingdom, where the fight between mining unions, who wanted to preserve the importance of coal-fired power, and the Thatcher-led conservative government, which wanted to curb the power of the unions by reducing reliance on coal coincided with Chernobyl's meltdown. We document that Members of Parliament (MPs) who are sponsored by mining unions speak more negatively about nuclear energy in parliament after Chernobyl compared to other MPs, even those from the same (Labor) Party. Due to the regulatory structure of energy in the U.K., parliament rarely votes on nuclear policy. Thus, we cannot examine voting behavior. Nevertheless, the U.K. results align with the U.S. evidence that anti-nuclear interests took advantage of Chernobyl to fight against nuclear expansion.

We also use data on global NPPs during a fifty year period to document that the sudden halt in NPP growth after Chernobyl is not unique to the U.S. There is a global slowdown in NPP growth after Chernobyl. Interestingly, it is driven by countries with open democratic systems like the U.S. and the U.K., which were the richest countries with the most NPPs at the time. Thus, the possibility

that the slowdown in nuclear energy investment is partly driven by anti-nuclear special interests taking advantage of Chernobyl to influence policymakers may be generalizable to other democratic systems. This is an important question for future research.

In the final part of the paper, we examine the effect of reduced nuclear investment on downstream outcomes. First, we consider safety. A reduction in the number of NPPs means that there are fewer reactors that can melt down. But the stop of new construction also means less adoption of newer models (Generation III+) that are much safer, and the continued use of older models past their expiration dates to meet energy demands. Using data on the age, model and incidents (accidents below the level of meltdowns) of NPPs, we document that the average age and incident risk increases in the U.S. and other democracies after Chernobyl. Second, we consider air pollution and, by extension, public health. Using data on the location of NPPs and satellite-based pollution measures from 2000–2020, we find that the operation of new nuclear reactors can significantly reduce ambient pollution levels in nearby metropolitan areas, likely reflecting a shift from fossil fuels to nuclear energy. Together with off-the-shelf estimates linking air pollution to health outcomes, our results suggest that the global decline in NPPs after Chernobyl led to a loss of 141 (318) million life years since 1986 in the United States (world).

Note that it is beyond the scope of our paper to make definitive welfare statements because we are unable to fully assess meltdown risks, the economic effects of fossil fuel or nuclear energy via channels such as employment or the geopolitical costs and benefits of the two energy sources.

Our paper is the among the first to systematically study the causes of the stagnation in nuclear energy investment, or provide evidence on the political economy drivers. It contributes to three strands of the literature. First, the findings speak to the growing literature on the economics of nuclear power. In the U.S., existing works have documented that deregulation of the electricity market in the late 1990s led to improved efficiency of nuclear power plants (Davis and Wolfram, 2012), which did not cause any detectable deterioration in safety standards (Hausman, 2014); and the closure of a major nuclear power plant in 2012 left a generation void that was filled by additional in-state natural gas generation, which increases generation costs and carbon dioxide emissions (Davis and Hausman, 2016). Most relatedly, Jarvis, Deschenes and Jha (2022) finds that when Germany closed half of its nuclear power plants following the Fukushima accident in 2011, local air pollution increased significantly due to the burning of more fossil fuel, which leads to a social cost of three to eight billion Euros per year, suggesting that policy-makers substantially overestimate the risk/cost of nuclear accidents in their

cost-benefit analysis of nuclear regulations. Our paper complements Jarvis et al. (2022) by showing that the environmental impacts of nuclear power plant closure exist globally over a longer range of time, and by investigating the political economic mechanisms that lead to such inefficient policy outcomes.

Second, this paper adds to our knowledge on the political economic determinants of environmental policies in democratic regimes. A long-standing literature on the politics of environmentalism has studied how interest groups lobby to affect environmental policies in their favor (e.g., Oates and Portney, 2003). More recently, List and Sturm (2006) finds that governors facing close re-election races may adjust environmental spending to win over "single issue voters" who prioritize environmental issues. Knittel (2006) shows that interest group strength affects the adoption of state-level electricity regulation. Cragg and Kahn (2009) documents that higher emissions lead to lower voting for carbon-reducing legislation. Stokes (2016) documents that anti-renewable-energy groups could mobilize voters to punish incumbents for their climate policies. Holland, Hughes, Knittel and Parker (2015) finds that campaign finance plays an important role in blocking more efficient climate policies. Shapiro (2021) shows that as a result of industries lobbying for low tariffs on their inputs, import tariffs and non-tariff barriers are substantially lower on dirty than on clean industries across most countries globally. Our paper complements these earlier studies by investigating the roles of special interest groups in deterring nuclear development, and by quantifying the associated safety and environmental costs.

Third, our findings also contribute to the literature on campaign finance. How corporations' campaign donations affect roll-call votes pertinent to their profitability has long attracted much interest from economists and political scientists (Silberman and Durden, 1976; Kau, Keenan and Rubin, 1982; Chappell Jr, 1981), but the empirical findings remain mixed among studies with more recent data and empirical designs (Stratmann, 1995, 2002; Mian, Sufi and Trebbi, 2010; Bronars and Lott, 1997; Ansolabehere, De Figueiredo and Snyder Jr, 2003). Our finding of the strengthened relationship between fossil fuel donations and anti-nuclear votes after Chernobyl complements the existing works by demonstrating that, even for the same congressman, the effectiveness of campaign donations in swaying roll-call votes can vary substantially based on contemporaneous political economic shocks.[3] To the best of our knowledge, by documenting a surge in fossil fuel donations after Chernobyl, we are also among the first to show that an increase in the marginal return to campaign contributions would increase, rather than decrease campaign contributions. More broadly, our paper also relates to the

[3]Relatedly, motivated by Hall and Wayman (1990); Snyder Jr (1992); Kroszner and Stratmann (1998), we also examine the impact of fossil fuel donations on legislators' participation in nuclear-related committees, and find suggestive evidence for a positive association after Chernobyl.

larger strands of literature on special interest politics and money in politics (Grossman and Helpman, 1994, 1996, 2001; Kang, 2016; Bombardini and Trebbi, 2011; Kim and Milner, 2019).

The paper is organized as follows. Section 2 presents the background. Section 3 investigates how the fossil fuel industry shaped the post-Chernobyl U.S. nuclear policies. Section 4 examines the generalizability of the U.S. results, by presenting evidence from the U.K. as well as cross-country analysis. Section 5 discusses the downstream effects of reduced nuclear energy on nuclear energy safety and air pollution. Section 6 concludes.

2 Background

2.1 Nuclear Power Plants

A nuclear reactor first generated electricity on September 3, 1948, in the United States, and power was fed into an electric grid for the first time on June 27, 1954, in the Soviet Union. The world's first full-scale power station opened in 1956 in the United Kingdom. According to the International Atomic Energy Agency (IAEA), 441 nuclear reactors are currently operating in 30 countries worldwide.

Uranium or plutonium serves as fuel for nuclear power plants. While nuclear power involves high capital costs for construction and maintenance, its direct fuel costs are comparatively low. We will later discuss the additional regulatory costs of nuclear power.

Nuclear power is highly stable; its capacity factor — defined as the ratio of actual energy production to maximum possible output — is 2.8 to 3.8 times higher than that of other energy sources. At the same time, nuclear energy is relatively clean: annual emissions of NOx (a smog precursor), SO2 (which contributes to acid rain and haze), and CO2 (a greenhouse gas) are less than one percent of the fossil-fuel average (Batkins, Rossetti and Goldbeck, 2017). The main environmental cost is radioactive waste disposal. In principle, spent nuclear fuel can be recycled to alleviate disposal challenges, but in practice, fuel and disposal prices have been so low that large-scale recycling of NPP waste has not taken hold.

Many argue that, since the late 1980s, regulation has slowed most new NPP construction. Regulation can improve plant safety and efficacy, but it can also increase costs (Institute for Energy Research, 2018). Moreover, regulatory standards often change during construction, leading to uncertainty. While specific processes vary across countries, a common issue is that regulatory authorities often cannot commit to fixed requirements at any point in the construction process. Regulators and citizens may

protest after a plant is approved but before it is finished, prompting new mandates mid-construction and causing significant cost overruns (Hess, 2018).

The Institute for Energy Research (IER) identifies regulatory costs as a key factor discouraging new development. One study of NPP construction similarly concludes that licensing, regulatory delays, and back-fit requirements are significant drivers of rising costs (Institute for Energy Research, 2018; Lovering, Yip and Nordhaus, 2016). The problem is particularly acute in democracies, where voter and special interest group influence can add layers of complexity. In the United States, the American Action Forum (AAF) estimates that the average nuclear plant faces an annual regulatory burden of around $60 million—$8.6 million in regulatory costs, $22 million in Nuclear Regulatory Commission (NRC) fees, and $32.7 million in regulatory liabilities (Institute for Energy Research, 2018). Of the 51 reactors under construction globally, only three are in Western and Central Europe (the UK, France, and Finland), and two are in the U.S. (World Nuclear Association, 2019; Cross, 2019).

In the U.S., obtaining NRC approval for a NPP can take six to seven years. Construction afterward can range from decades to indefinite, and escalating costs and shifting regulations sometimes force cancellations after substantial sunk investments. Globally, companies have halted construction on 90 reactors since the 1980s, including 40 in the U.S. In 2017, two South Carolina utilities abandoned two partially built Westinghouse AP1000 reactors because of major delays and cost overruns, leaving only two other AP1000 reactors under construction in Georgia. Their original estimated cost of $14 billion rose to $23 billion, and work continued only after federal government support was secured. These were the first new reactors built in the U.S. in decades. In contrast, recent NPP projects in China (South Korea) have taken only 68 (56) months to build and cost about $2 ($9) billion per reactor. Another relevant benchmark is a typical natural gas plant, which can generally be constructed in about two years (Lovering et al., 2016).

2.2 Chernobyl

There have been three major reactor meltdowns in history. The first was a partial meltdown at the Three Mile Island reactor in Pennsylvania on March 28, 1979. The Chernobyl disaster — the primary focus of this study — occurred on April 26, 1986, in the northern region of the Ukrainian SSR in the Soviet Union. The Fukushima Daiichi nuclear disaster took place on March 11, 2011, in Ōkuma, Fukushima Prefecture, Japan. On the seven-point International Nuclear Event Scale (INES), the Three Mile Island accident is rated at Level 5 ("Accident with Wider Consequences"), while Chernobyl and

Fukushima are rated at Level 7—the maximum severity.

The Soviet government delayed informing local residents about the disaster for 36 hours. Over the next two days (April 27–28, 1986), Swedish air monitors detected large amounts of radiation originating from the USSR, and U.S. satellite images confirmed the extent of the meltdown.[4] On April 28, Soviet news outlets acknowledged the accident, prompting extensive worldwide media coverage.

Unless otherwise stated, all information below is drawn from The Chernobyl Forum (Kinley III, 2006).

The Chernobyl reactor meltdown resulted from operator negligence and critical design flaws. The reactor core melted, and subsequent explosions ruptured the core and destroyed the reactor building. An open-air reactor core fire followed, releasing airborne radioactive contamination for about nine days. Winds blew primarily north and west, with around 70% of the fallout landing in the Belarus SSR, which experienced "black rain." Significant fallout also affected the Ukrainian and Russian SSRs. Additional deposits occurred in mountainous regions such as the Austrian and Swiss Alps, the Welsh mountains, and the Scottish Highlands, where adiabatic cooling caused radioactive rainfall. Sweden and Norway received heavy fallout when contaminated air encountered a cold front. Other affected countries included Finland and Bulgaria. Groundwater generally remained unharmed except within the exclusion zone around Chernobyl, where waste disposal practices caused contamination. Radioactive fish raised short-term concerns in parts of the U.K. and Germany, while long-term worries persisted in Ukraine, Belarus, Russia, and parts of Scandinavia.

A protective "sarcophagus" was built around the Chernobyl site by December 1986, followed by a second containment structure in 2017. The immediate emergency response, combined with subsequent decontamination efforts, required more than 500,000 personnel and cost an estimated $68 billion (2019 USD). Between five and seven percent of Ukraine's government spending remains tied to Chernobyl-related expenses. In Belarus, such expenditures fell from 22% of the national budget in 1991 to 6% by 2002.

The RBMK reactor design used at Chernobyl was common in Central and Eastern Europe. After the accident, all RBMK units underwent examination and retrofitting to address the design deficiencies that contributed to Chernobyl. Authorities also undertook major initiatives to improve shutdown mechanisms, operational safety, and regulatory oversight.

The Chernobyl accident drew worldwide attention and raised far greater alarm about nuclear safety

[4] https://www.history.com/news/chernobyl-disaster-timeline

than the earlier Three Mile Island incident. In direct response to Chernobyl, the International Atomic Energy Agency strengthened its safety protocols: member states pledged to notify one another of nuclear or radiation accidents within their jurisdictions that might affect other nations and to provide mutual assistance in radiological emergencies.

Chernobyl had a notable negative effect on public opinion regarding nuclear power. Although systematic polling data from that period are limited, a Finnish survey found that the share of individuals with a positive view of nuclear energy dropped from 35% to 22% immediately after Chernobyl, while negative attitudes rose from 32% to 44% (OECD, 2010). The impact of large meltdowns on public opinion is even clearer in the case of Fukushima, for which there exist more comprehensive polling data. In the United States, for example, Gallup polling showed that public support for nuclear energy fell from 62% in 2010 (one year before Fukushima) to 44% in 2016 (Riffkin, 2016).

2.3 U.S. Nuclear Investment Before and After Chernobyl

The United States was a global leader in nuclear power, and despite the Three Mile Island accident in 1979, the U.S. remained the largest investor in nuclear energy in the early 1980s. Using reactor-level data from the Power Reactor Information System (PRIS) maintained by the International Atomic Energy Agency (IAEA), Figure 1 plots the number of NPPs over time for the U.S.. We observe a steep rise in nuclear investment during the 1960s, 70s and early 1980s, even after the Three Mile Island partial meltdown. After Chernobyl, however, the number of operating nuclear reactors fully stopped growing in the U.S.

The fact that nuclear investment in the U.S. plummeted after the Chernobyl accident could potentially be explained by the U.S. government having high levels of accountability regarding its citizens safety concerns. That said, it is also possible that, powerful special interest groups, such as the fossil fuel industries in these regions, also tried to take advantage of the safety concerns arising after Chernobyl to reduce nuclear investment.

In the U.S., opposition to nuclear came mainly from two sources. The first was the fossil fuel industry. Nuclear energy competed with other energy providers. In the 1980s, most non-nuclear energy came from fossil fuels. Thus, the expansion of nuclear energy was a direct threat to the profits and relevance of fossil fuel, and the fossil fuel industry responded by actively fostering an anti-nuclear agenda through both political lobbying and media campaigns.

As an example for fossil fuel lobbying, throughout the 1960s, the coal industry invested significant

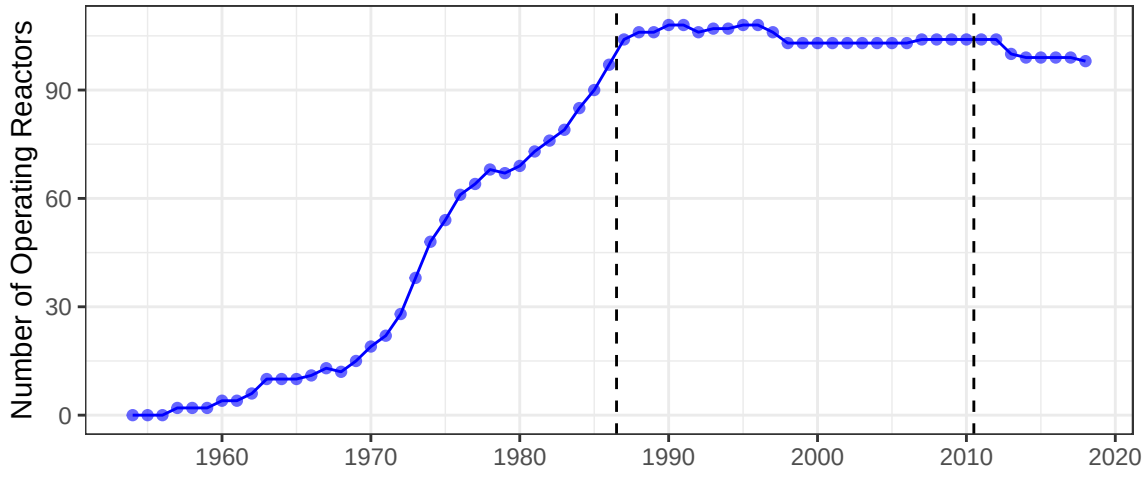


Figure 1: The Rise and Stagnation of Nuclear Reactors in the US

resources in a lobby group called the National Coal Policy Council (NCPC), which was an alignment that included coal mining companies, coal miner unions, railroad companies, coal mine equipment companies and coal-burning utility companies. The NCPC directly challenged the federal government's programs designed to make the peaceful atom an economically viable competitor against fossil fuel.[5]

In terms of fossil fuel media influence, an example can be found in how the Rockefeller Foundation, established by Standard Oil magnate John D. Rockefeller, cultivated anti-nuclear sentiments and popularized it via the New York Times. Specifically, it has been documented that in 1954, the then President of the National Academy of Sciences (NAS), who was on the board of trustees of the Rockefeller Foundation, was asked by several of his fellow trustees to compile a report on the risk of atomic radiation. The report ended up being highly critical of atomic radiation than previous standards (and was later criticized by some for exaggerating radiation risk), and was promoted extensively in the New York Times, whose publisher at the time was also a trustee of the Rockefeller Foundation.[6]

In addition to the fossil fuels, another source of opposition to nuclear power came from environmental groups. Starting in the mid 1970s, groups such as the Sierra Club in the U.S. began to lobby against nuclear energy (Environmental Progress, 2023). It is later pointed out that, behind many anti-nuclear activities carried out by environmental groups at the time, one can find the fingerprints

[5]Source: https://atomicinsights.com/above-board-competition-in-energy-markets-finally-emerging/

[6]For more details, see: https://atomicinsights.com/how-did-leaders-of-the-hydrocarbon-establishment-build-the-foundation-for-radiation-fears/

of the fossil fuel industry. For example, in 1970, the head of the Atlantic Richfield Co., a major U.S. petroleum company at the time, contributed $200,000 to Friends of the Earth, which helped promote strongly anti-nuclear positions (Engdahl, 1993).[7]

Motivated by the rich anecdotal evidence, in Section 3, we explicitly investigate the role played by the fossil fuel industry in shaping the post-Chernobyl nuclear regulations in the U.S. Note that the government's accountability regarding nuclear risk and the influence of fossil fuel special interest are not mutually exclusive explanations to the decline of nuclear energy investment in the U.S. This paper focuses on the latter, due to the previously lacking rigorous evidence on the importance of this channel.

3 The United States

To rigorously understand the role of the fossil fuel industry in shaping anti-nuclear policies in the U.S., our analysis will examine the relationships between fossil fuel donations and voting on nuclear-related bills in the House and Senate, and between fossil fuel advertisements and news coverage about nuclear energy in major newspapers, with a focus on how these relationships changed before and after the Chernobyl accident.[8] In addition, we also investigate whether the Chernobyl accident affected fossil fuel campaign contributions and advertisement spendings.

3.1 Salience of the Chernobyl Accident among the U.S. Public

Before we begin our analysis, we will first document that the Chernobyl accident was salient to the American public and that it triggered widespread fear and concern about nuclear safety in the U.S.. News reports of Chernobyl started on April 28th, within three days after the meltdown. It was widely reported in all major news outlets and mediums: print, radio, and television.

As an example for the salience of the news, we examine articles with the word "Chernobyl" published in four major U.S. newspapers at the time — the New York Times, Wall Street Journal, Los Angeles Times, and Chicago Tribune. Specifically, Figure 2a plots the trend of articles in these four outlets mentioning the word "Chernobyl." It shows a sudden and dramatic increase in news about Chernobyl that lasts for several months. Figure 2b plots the number of nuclear-related articles that mention

[7] In 2007-2010, the Sierra Club accepted $25 million USD from an energy company (Walsh, 2012).

[8] Note that we are unable to observe gifts or spending for environmental organizations because most of them are private and do not disclose such information. Also, there is no systematic data on the patrons behind non-commercial advertisements.

"safety," "fallout," or "meltdown"; and Figure 2c plots the number of generally anti-nuclear articles over time. We extract all news articles related to nuclear energy, and use ChatGPT to help identify whether an article is generally anti-nuclear. The figures show that the number of both types of articles (which are not mutually exclusive) increased after Chernobyl. These figures are consistent with the conventional wisdom that knowledge about the accident was pervasive in the U.S. and there was significant public concern over the safety of NPPs.

We also examine the number of articles that mentioned "Three Mile Island" to see if news outlets linked the two reactor accidents. Figure 2d shows that these four newspapers indeed began mentioning "Three Mile Island" more frequently immediately following the Chernobyl accident.

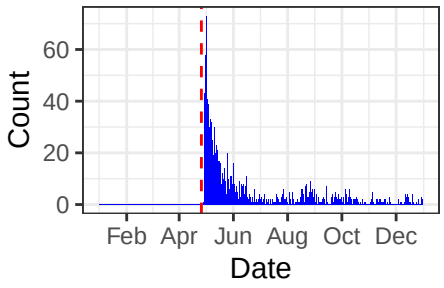
3.2 Fossil Fuel Donations and Congressional Voting on Nuclear Bills

U.S. nuclear energy development is regulated by the Nuclear Regulator Commission (NRC), an independent agency created by Congress in 1974. The NRC is ultimately overseen by Congress, which votes on bills that specify the NRC's mandate, funds, sets objectives, such as increasing or reducing regulations, research, the number of reactors, etc.

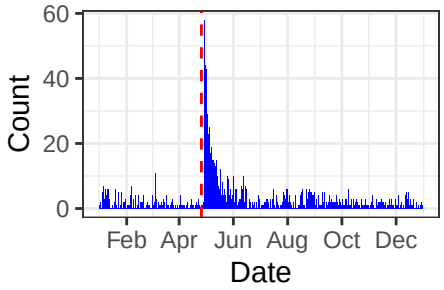
To understand the extent to which the fossil fuel industry can influence nuclear energy policies through campaign donations, and how this channel of potential policy influence responds to the Chernobyl accident, we link campaign donations by large fossil fuel companies to the recipients' congressional voting records in nuclear-related bills.[9] We manually label each nuclear-related bill as pro- or anti-nuclear based on how the proposed policy would likely affect the profit and operational costs of the nuclear industry. Appendix A provides examples of these nuclear-related bills. This in turn allows us to define three outcome variables at the congressman-by-bill level: i) *Pro Nuclear Vote*, a dummy variable that equals one if a congressman votes pro in a pro-nuclear bill or against in an anti-nuclear bill; ii) *Anti Nuclear Vote*, a dummy variable that equals one if a congressman votes pro in an anti-nuclear bill or against in a pro-nuclear bill; and iii) *Absentia*, a dummy variable indicating whether a congressman is in absentia in a nuclear-related bill.

Our hypothesis is that, for a given congressman voting on a given bill related to nuclear energy, receiving fossil fuel donations might make him less likely to vote pro-nuclear and more likely to vote

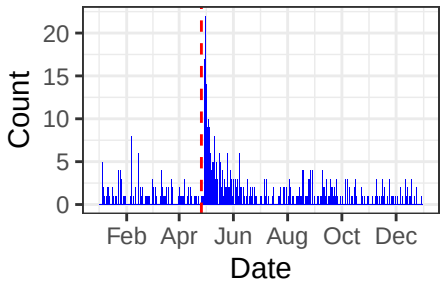
[9] Congressional voting records are from voteview.com, and nuclear-related bills are identified by keyword filtering and manual checking.



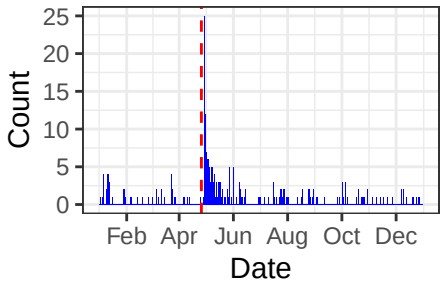
(a) Number of Articles about Chernobyl in US Newspapers in 1986



(b) Number of Articles Mentioning "safety", "fall-out" or "meltdown" in US Newspapers in 1986



(c) Number of Anti-nuclear Articles in US Newspapers in 1986



(d) Number of Articles about Three Mile Island in US Newspapers in 1986

Figure 2: Number of Nuclear-related Articles in US Newspapers in 1986

anti-nuclear. We expect to observe such an effect after Chernobyl since the accident likely increased the returns to lobbying, which could happen if public fear complements lobbying efforts in the congress member's decision process. It can also happen if there are increasing returns to the amount of contribution (i.e., the relationship between the amount of fossil fuel contributions and anti-nuclear votes is convex).

To investigate, we estimate the following equation:

$$vote_{ijt} = \alpha \text{Fossil Donations}_{it} + \beta \text{Fossil Donations}_{it} \times post_t + \lambda_i + \tau_j + \gamma_t + \epsilon_{ijt}, \tag{1}$$

where the voting behavior of congressman i on bill j in cycle t, $vote_{ijt}$, is a function of: donations he received from fossil fuel firms, Fossil Donations$_{it}$, and its interaction with a dummy variable for post Chernobyl, $post_t$; a vector of congressman fixed effects, λ_i, bill fixed effects, τ_j, and cycle fixed effects, γ_t. Standard errors are clustered at the state level.

Table 1 column (1) examines the likelihood of voting pro-nuclear amongst all nuclear-related bills, column (2) examines the likelihood of abstentions amongst all nuclear-related bills, and column (3) examines the likelihood of voting anti-nuclear amongst all nuclear-related bills. In Column (4), we attempt to combine the patterns in the first three columns by estimating an Ordered Logistic Regression, where the outcome is ordered as "pro-nuclear," "absentia," and "anti-nuclear."

Column (1) shows that prior to Chernobyl, campaign contributions from fossil fuel are not systematically associated with pro-nuclear votes, while after Chernobyl, contributions are strongly and negatively associated with voting pro-nuclear. Quantitatively, the interaction term indicates that after Chernobyl, a congressman receiving 100,000 USD in campaign donations from fossil fuel is 11.0% less likely to cast pro-nuclear votes, compared to their peers who vote on the same bill without receiving any fossil fuel donation. In column (2), fossil fuel donations are not associated with abstentions in nuclear-related bills in either the pre- or the post-Chernobyl era. In column (3), we observe the opposite patterns for anti-nuclear votings. Prior to Chernobyl, campaign contributions from fossil fuel are not systematically associated with anti-nuclear votes, while after Chernobyl, contributions are strongly and positively associated with voting anti-nuclear

To better understand the dynamics of the effects, we separately estimate the impact of fossil fuel donations on nuclear-related vote by each cycle, and plot the estimates in Figure **??**. As can be seen, there does not seem to be any obvious pre-trend in the associations between fossil fuel donation and nuclear-related vote, but a strong correlation emerges immediately after Chernobyl. Since the number

Table 1: Fossil Fuel Donations and Congressman-bill Level Votes, 1979-1996

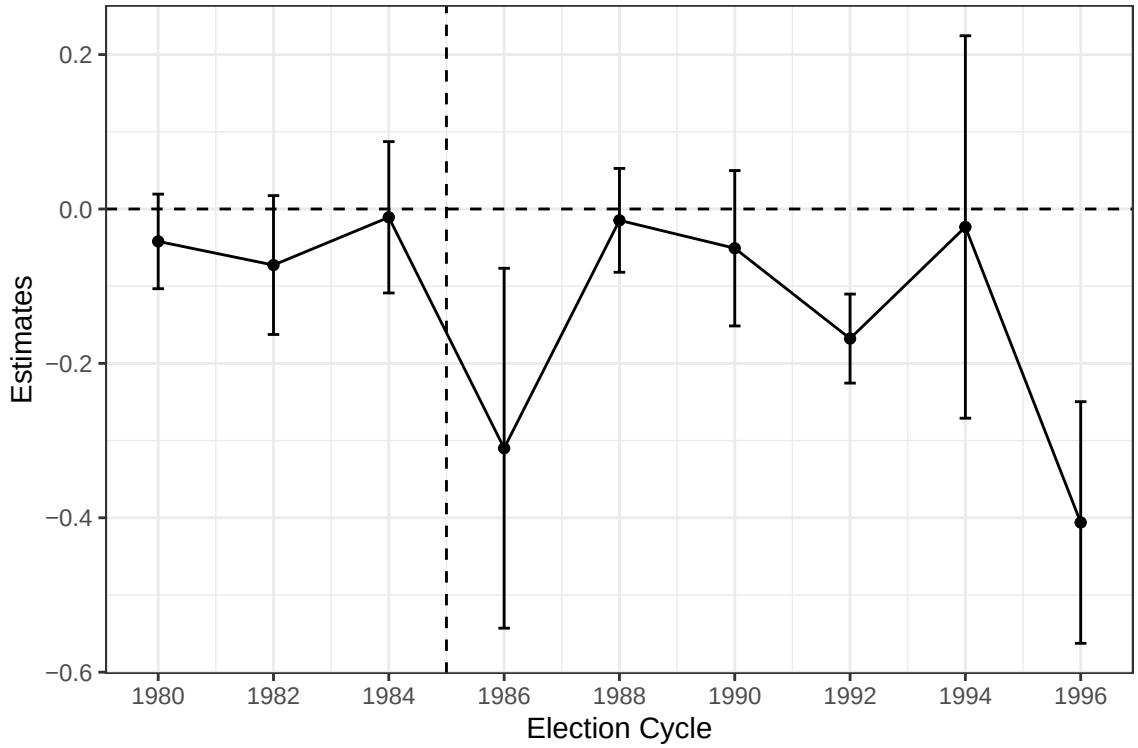
Dependent Variable	Pro-nuclear vote	Absent from voting	Anti-nuclear vote
	(1)	(2)	(3)
Fossil Donation (in 100k USD)	0.032	0.029	-0.059
	(0.035)	(0.027)	(0.036)
Post Chernobyl × Fossil Donation (in 100k USD)	-0.110***	-0.014	0.120***
	(0.037)	(0.025)	(0.039)
Sum of Coeff.	-0.079	0.016	0.061
P-value of the sum	0.000	0.262	0.004
Pre-period Dep. Var. Mean	0.315	0.127	0.556
Post-period Dep. Var. Mean	0.421	0.040	0.539
N	18012	18012	18012
R2	0.42	0.18	0.36
Cycle FE	X	X	X
Congressman FE	X	X	X
Bill FE	X	X	X

Notes: The standard errors in parentheses are clustered at the state level. * p < 0.1, ** p < 0.05, *** p < 0.01.

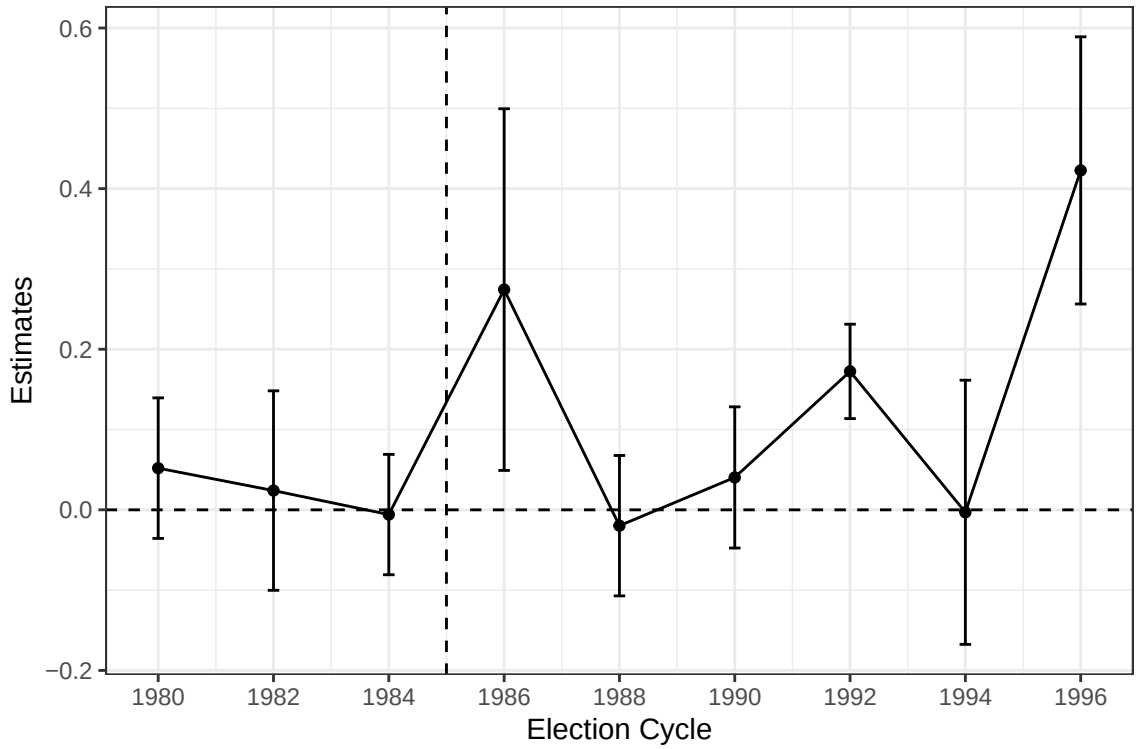
and nature of nuclear-related bills vary substantially across cycles, the precision of our estimates vary accordingly, and the magnitudes of coefficients in different periods are not necessarily comparable to each other. Nevertheless, we do observe a general persistence in the association between fossil fuel donations and nuclear-related votes in the decade following 1986, which is consistent with the interpretation that the Chernobyl accident raised the long-term return to anti-nuclear lobbying.

Important Nuclear Bills Not all bills are equally important. To gauge the economic significance of fossil fuel influence in nuclear policy making, we construct two measures that can proxy for the importance of a nuclear-related bill. The first measure is "high-stakes," for which we read through the bills and manually code high-stakes bills as those that directly affect nuclear development and investment in economically significant ways. There are 37 such high-stakes bills, which we lay out in Appendix Table A.2. The second measure is "pivotal," which refers to the subset of bills where yes-votes are within a 15% margin of reaching majority (i.e., within 35% to 65% of all votes).

In Table 2, we modify our baseline interaction specification, by further interacting Fossil Donations$_{it}$ and Fossil Donations$_{it} \times post_t$ with the two measures of bill importance — $HighStakes_j$ and $Pivotal_j$. As shown in columns (1), (3), (4) and (6), the baseline findings on pro- and anti-nuclear votes appear to be entirely driven by those pivotal and high-stakes bills. There is no similar impact on absentia. We observe that pre-Chernobyl fossil fuel donations are associated with more (fewer) pro-nuclear (anti-nuclear) votes in pivotal or high-stakes bills. This could reflect two possible scenarios. First, the



(a) Dynamic Effect of Fossil Fuel Donation on Pro-nuclear Votes



(b) Dynamic Effect of Fossil Fuel Donation on Anti-nuclear Votes

Figure 3: Dynamic Effect of Fossil Fuel Donation, 1979-1996

selection of fossil fuel donations: when a congressman is more likely to vote more pro-nuclear in a bill that is either important or pivotal, fossil fuel companies have stronger incentives to attempt to sway his votes; the fact that the congressmen remain more pro-nuclear even after receiving fossil fuel donations therefore speaks to the lack of effectiveness in fossil fuel lobbying prior to Chernobyl. Second, the most high-stakes and pivotal bills tend to be more visible to the media and general public, so congressmen receiving fossil fuel donations have particularly strong incentives to "lie low" in these bills to avoid being seen as corrupted by fossil fuel.

The Chernobyl accident, by making anti-nuclear sentiment a generally acceptable attitude, makes it easier to sway a given congressman while also alleviating his concerns about being viewed as corrupt. As a result, after the Chernobyl accident, as reflected by the significant triple interaction terms, the recipients are no longer more pro-nuclear in their subsequent votes in important/pivotal bills, indicating increased lobbying effectiveness by the fossil fuel industry.

Taken together, our results indicate that the fossil fuel influence in post-Chernobyl nuclear policy making is substantive, rather than just performative: by mostly swaying congressional votes in pivotal and high-stakes nuclear bills, fossil fuel donations might have shaped U.S. nuclear policies in economically significant ways.

Another potentially interesting outcome is the sponsorship of nuclear-related bills. However, only a very small number of elected officials ever sponsor such bills and we have too little meaningful variation for estimation.

3.3 Fossil Fuel Campaign Contributions after Chernobyl

Our findings so far suggest that the Chernobyl accident increased the marginal return to anti-nuclear lobbying, which is consistent with a scenario where the accident shifts congressmen from being staunchly pro nuclear to being open to the idea of opposing nuclear investment. In theory, since lobbying is an intermediate input to the final output of "anti-nuclear influence/policy," such an increase in the return to lobbying could have ambiguous impacts on the amount of lobbying effort. For example, when it becomes easier to convince congressmen to vote anti-nuclear, fossil firms may either increase their lobbying expenditure (anti-nuclear policies become "cheaper," increasing demand for such policies), or decrease it (the desired anti-nuclear policy requires less lobbying expenditure to achieve, leading firms to substitute resources to other domains). To investigate whether fossil fuel interest groups

Table 2: Fossil Fuel Donations and Congressman-bill Level Votes on Important Nuclear Bills, 1979-1996

Dependent Variable	Pro-nuclear vote (1)	Absent from voting (2)	Anti-nuclear vote (3)	Pro-nuclear vote (4)	Absent from voting (5)	Anti-nuclear vote (6)
Fossil Donation	0.029	0.027	-0.051	0.032	0.046	-0.074*
	(0.040)	(0.023)	(0.040)	(0.037)	(0.033)	(0.043)
Post Chernobyl	-0.052	-0.004	-0.054	0.009	-0.026	0.010
× Fossil Donation	(0.043)	(0.025)	(0.041)	(0.041)	(0.034)	(0.051)
Fossil Donation	0.040	0.018	0.052			
× High-stake Bill	(0.084)	(0.083)	(0.045)			
Post Chernobyl	-0.172*	-0.037	0.212*			
× Fossil Donation	(0.098)	(0.085)	(0.125)			
× High-stake Bill						
Fossil Donation				0.004	-0.046	0.035
× Pivotal bill				(0.058)	(0.041)	(0.074)
Post Chernobyl				-0.237***	0.038	0.207**
× Fossil Donation				(0.079)	(0.042)	(0.091)
× Pivotal bill						
Pre-period	0.315	0.127	0.556	0.315	0.127	0.556
Dep. Var. Mean						
Post-period	0.421	0.040	0.539	0.421	0.040	0.539
Dep. Var. Mean						
N	18012	18012	18012	18012	18012	18012
R-squared	0.42	0.18	0.36	0.42	0.18	0.36
Cycle FE	X	X	X	X	X	X
Congressman FE	X	X	X	X	X	X
Bill FE	X	X	X	X	X	X

Notes: The standard errors in parentheses are clustered at the state level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

leverage Chernobyl to lobby against nuclear investment, we examine campaign contributions from fossil fuel companies to the members of Congress before and after Chernobyl. In the presence of the aforementioned countervailing forces, our estimates will capture the net average effect.

This analysis uses a firm-by-cycle level panel that starts from the 1979-80 cycle, the beginning of the campaign contribution records documented in the Database on Ideology, Money in Politics, and Elections (DIME), and ends in the 1995-96 cycle, a decade after the Chernobyl accident. For all Fortune 500 firms, and all other fossil fuel firms with an annual revenue larger than 100 million USD in 1985, we search its profile in DIME to map out its campaign contribution records throughout our sample period. We keep every firm that ever made at least one campaign contribution during the entire sample period, and end up with 90 fossil fuel firms and 325 non-fossil-fuel firms in the baseline sample.

The dynamic pattern of fossil fuel campaign donations before and after Chernobyl is characterized by the following event study specification:

$$Log(Donations_{it} + 1) = \sum_{k \neq -1} \beta_k Fossil_i \times \mathbb{1}\{t = k\} + \lambda_i + \gamma_t + \epsilon_{it}. \tag{2}$$

where $Donations_{it}$ is the amount of donations from firm i during cycle t. $Fossil_i$ is equal to 1 if the firm is in the fossil-fuel industry, $\mathbb{1}\{t = k\}$ represents the vector of event study dummies where the cycle immediately before Chernobyl is omitted for comparison. λ_i is a vector of firm fixed effects and γ_t is a vector of cycle fixed effects. Standard errors are clustered at the firm level. Firm fixed effects account for time-invariant differences across firms such as the fact that firms vary in size and some firms always donate more than other firms. Cycle fixed effects account for changes over time that affect all firms, such as the fact that campaign donations have generally increased over time.

Figure 4 plots the coefficients. There are no pre-trends. Prior to the Chernobyl accident, the fossil fuel industry had similar trajectories in campaign contributions as other firms. After Chernobyl, we observe a relative increase in campaign donations from fossil fuel firms. The timing of the pattern is reassuring, as fossil fuel companies increase contribution precisely after Chernobyl. The Chernobyl effect is persistent throughout the subsequent decade, suggesting a permanent change in the return to fossil fuel lobbying.

In Table 3, we quantify these effects by estimating the corresponding DiD specification. Column (1) examines the log of donations plus 1 to allow for observations that make no donations. Column (2) examines the log of donations without adding one – i.e., the intensive margin. All observations

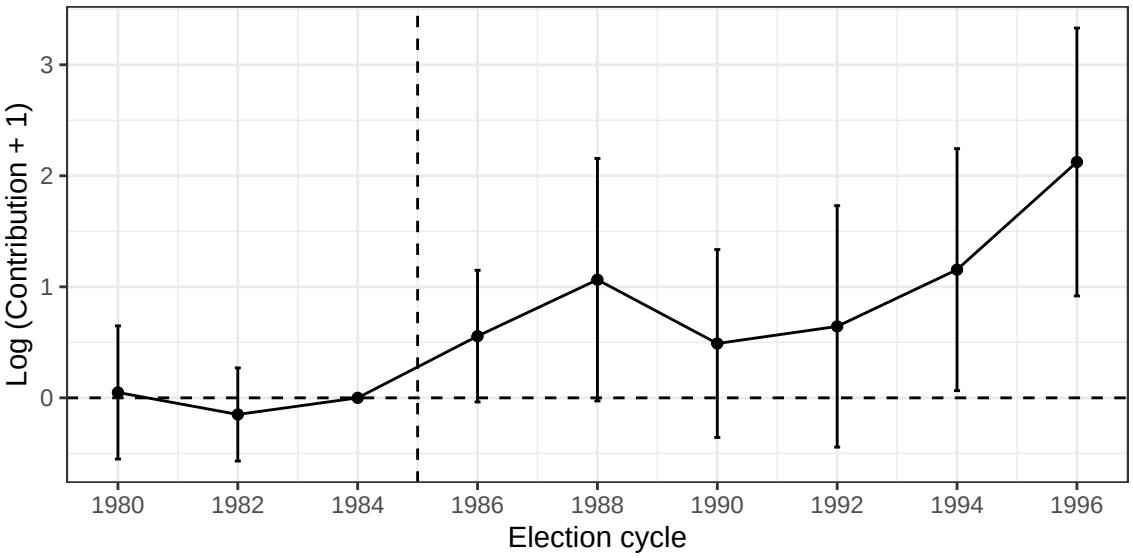


Figure 4: Event study for donations from fossil energy firms, 1979-1996

that do not make any donations drop out of the estimate. Column (3) examines a dummy variable for any donation – i.e., the extensive margin. All observations that never made any donations drop out of the estimate. The DiD estimates confirm the event study patterns: fossil fuel campaign contributions increased by 103.9% in the decade immediately following the Chernobyl accident, and the effect appears to be entirely driven by the extensive margin (all fossil fuel firms become 12.6% more likely to make campaign contributions), with no detectable effects on the intensive margin (no significant change in the average amount of donations). Overall, in the event of a major nuclear accident, large fossil fuel companies became more active in making campaign contributions.

Taken together, our analysis of U.S. politics shows that Chernobyl triggered significant public fear and concern about nuclear energy. At the same time, campaign contributions from fossil fuel companies increased after Chernobyl, and these contributions were associated with a strong shift towards voting more negatively on high-stakes and pivotal bills that affected the costs of constructing and maintaining nuclear reactors. These results are consistent with our hypothesis that the fossil fuel industry leveraged Chernobyl to stall U.S. nuclear investment.

3.4 Congressmen from Fossil-intensive States

In addition to the financial ties between congressmen and fossil fuel companies investigated above, which happen on a quid-pro-quo basis, congressmen can also be motivated by the more permanent

Table 3: Fossil Fuel Firms and Donations, 1979-1996

Dependent Variable	Log (Donation + 1)	Log (Donation)	Any Donation
	(1)	(2)	(3)
Post Chernobyl × Fossil Fuel Firms	1.039***	-0.123	0.126***
	(0.388)	(0.174)	(0.041)
Mean of Dep. Var.	5.398	10.312	0.523
S.D. of Dep. Var.	5.318	1.828	0.500
N	3735	1955	3735
R-squared	0.70	0.80	0.61
Cycle FE	X	X	X
Contributor FE	X	X	X

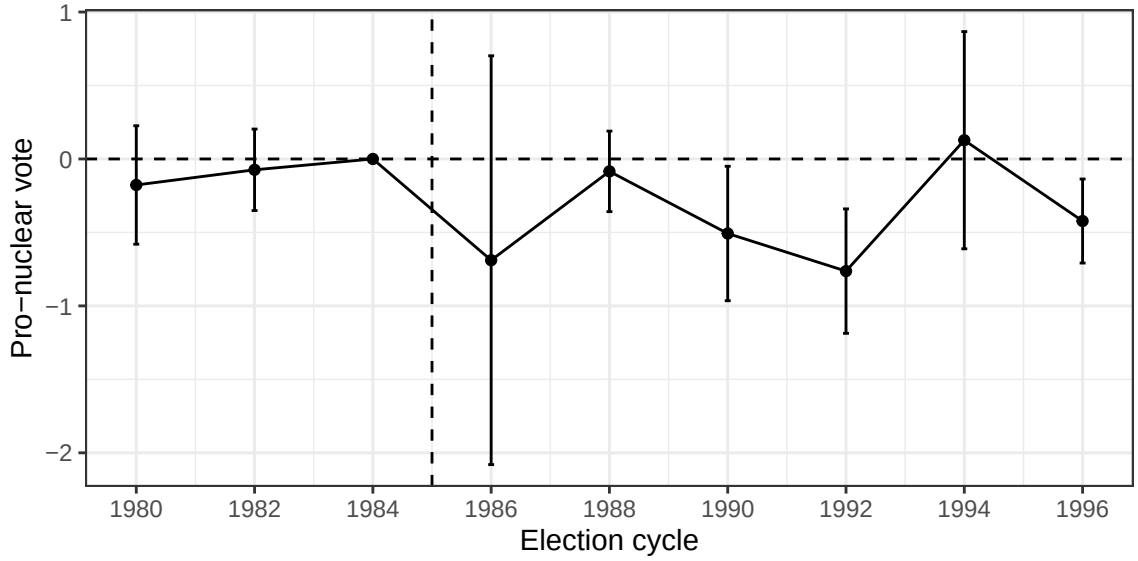
Notes: The standard errors in parentheses are clustered at the firm level. * p < 0.1, ** p < 0.05, *** p < 0.01.

economic interests of their constituencies. Specifically, congressmen from fossil-fuel-intensive states could be more responsive to the Chernobyl accident than their peers, in terms of their voting behaviors in nuclear-related bills.

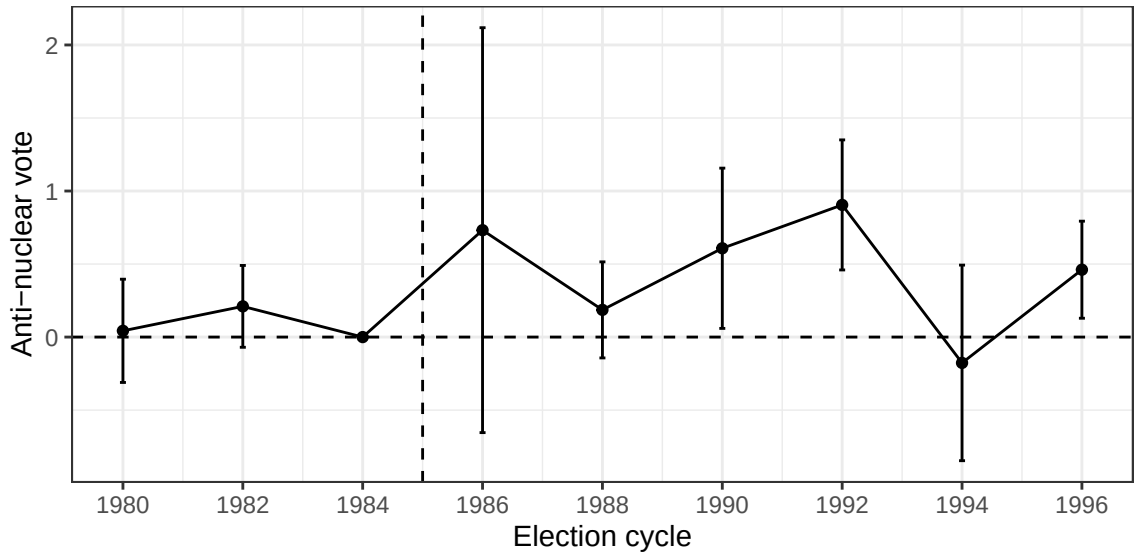
To investigate this hypothesis, we calculate each state's fossil fuel share of GDP in 1985 to proxy for its "fossil fuel intensity." We then interact this variable with year dummies to compare congressmen from fossil fuel intensive states to their peers, before and after the Chernobyl accident, and examine whether there is a significant break in trends in terms of their voting patterns in nuclear-related bills. We control for congressman fixed effects to absorb pre-existing differences in anti-nuclear stance, cycle fixed effects to control for the common trend in anti-nuclear sentiment, and bill fixed effects to restrict the comparison to be within the same proposed policy. The standard errors are clustered at the state level.

As shown in Figure 5, congressmen from fossil fuel intensive states become significantly less likely to vote pro-nuclear, and significantly more likely to vote anti-nuclear, immediately after the Chernobyl accident. Such effects persist throughout the subsequent decade. Table 4 quantifies such effects: following 1986, a 10% higher fossil fuel share of GDP is associated with a 2% reduction in the likelihood of voting pro-nuclear and a 3% increase in the likelihood of voting anti-nuclear. There is no detectable change in the likelihood of being in absentia (Column (2)). Appendix Table A.4 further reveals that such effects are more salient for high-stakes nuclear bills. We observe similar patterns for pivotal bills too, but lack the statistical power to draw precise conclusions.

In Appendix Table A.5, we also examine whether congressmen from fossil-fuel-intensive states received more campaign donations from fossil fuel companies after Chernobyl, and find no such evidence. This null result is consistent with the interpretation that congressmen can be swayed not only on a



(a) Pro-nuclear votes



(b) Anti-nuclear votes

Figure 5: Event study for pro- and anti-nuclear votes by congressmen from fossil-intensive states, 1979-1996

Table 4: State-level Fossil Fuel GDP Share and Congressman-bill Level Votes, 1979-1996

Dependent Variable	Pro-nuclear vote	Absent from voting	Anti-nuclear vote
	(1)	(2)	(3)
Post Chernobyl × State-level Fossil Fuel GDP Share	-0.230**	-0.096	0.324**
	(0.100)	(0.087)	(0.160)
Pre-period Dep. Var. Mean	0.315	0.127	0.556
Post-period Dep. Var. Mean	0.421	0.040	0.539
N	17958	17958	17958
R2	0.42	0.18	0.36
Cycle FE	X	X	X
Congressman FE	X	X	X
Bill FE	X	X	X

Notes: The standard errors in parentheses are clustered at the state level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. In Column 4, we use decile bins for state-level fossil fuel GDP share to achieve convergence.

quid-pro-quo basis, but also by the underlying economic interests of their constituencies, which can be driven by their incentives to maximize long-term votes and campaign contributions.

Congressmen on Nuclear-Related Committees Fossil fuel companies who wish to influence nuclear-related policies may target elected officials serving on committees for energy-related issues. House and Senate committees have a broad range of powers. They consider bills and issues, as well as recommend measures for consideration by Congress. Targeting members of nuclear-related committees can be viewed as a way to increase long-run influence and can avoid the public scrutiny that "Quid pro quo" effects on voting may attract Hall and Wayman (1990); Snyder Jr (1992); Kroszner and Stratmann (1998). We investigate whether Chernobyl increased fossil fuel donations to members of energy-related committee members. In Appendix Table A.3 column (1), we regress a dummy variable for whether a member of Congress is on an energy-related committee on the amount of donations from fossil fuel firm, its interaction with the post-Chernobyl dummy variable, election cycle fixed effects and state fixed effects. In column (2), we replace state fixed effects with Congressman fixed effects. The interaction coefficient is positive, which means that fossil fuel companies were more likely to target committee members after Chernobyl. However, it is insignificant in column (1) and only marginally significant in column (2). Note that the coefficient for the uninteracted fossil fuel donation in column (2) is difficult to interpret because there is little variation after controlling for Congressman fixed effects.

3.5 Fossil Fuels and U.S. News Outlets

In addition to making campaign contributions, another potential channel through which big companies can influence public policy is by shaping media discourse on topics of interest. Anti-nuclear advertisements might directly influence readers' opinions about nuclear energy, and qualitative evidence suggests that the fossil fuel industry has indeed been paying for anti-nuclear advertisements. But it is hard to evaluate the prevalence of such practice because there is no systematic data on the patrons behind non-commercial advertisements.[10]

Nevertheless, even advertisements that appear neutral or silent about nuclear energy, such as purely commercial advertisements for fossil fuel, can potentially affect anti-nuclear news coverage. This is the case if the management of profit-maximizing news outlets believes that their future advertisement revenues could be contingent on how they report on nuclear power, either directly so by influencing the fossil fuel's choice of advertisement platforms, or indirectly so by impacting the profits of fossil fuel firms and thus their advertisement expenditures. This would thus lead the news outlets to strategically decide on their coverage of nuclear energy. Such practice is quite prevalent, for example, as documented by Soley and Craig (1992), "a survey of editors at daily newspapers found that just under ninety percent reported that advertisers attempted to influence the content of stories appearing in their papers; ninety percent had economic pressure applied on them by advertisers because of their reporting; and thirty-seven percent had capitulated to advertiser pressure."

Therefore, in this section, we explore the relationship between fossil fuel advertisement spending and nuclear coverage in major U.S. newspapers. We obtain historical newspaper records in the U.S. from four databases: Proquest, Newsbank, Newspaper.com, and Newspaperarchive.com, and download all pages in the six months before and after Chernobyl for all the top 3 most circulated daily newspapers in each state as of 1986 (when available). Following Dell, Carlson, Bryan, Silcock, Arora, Shen, D'Amico-Wong, Le, Querubin and Heldring (2023), we apply a deep-learning OCR model, which is fine-tuned to identify newspaper layouts and convert the graphical newspaper copies into textual data. We then search in the newspaper contents the names of all the companies in the Fortune 500 list, including both fossil fuel and non-fossil-fuel ones. For each returned article, we ask ChatGPT to help identify whether it is an advertisement. We also extract all newspaper articles related to nuclear energy, and use ChatGPT to categorize each article's attitude as positive, negative, or neutral about nuclear energy.

[10]For example, the American Petroleum Institute was reported to organize opposition to pro-nuclear legislation in Harrisburg through an initiative called No Nuclear Bailouts. API has paid for social media ads and mail pieces hammering House Bill 11, which would include nuclear in the portfolio of "alternative energy" sources that count towards utilities' requirements for carbon-free power sources. Source: https://climatecoalition.org/who-opposes-nuclear-energy/

Table 5: Fossil Fuel and News Coverage of Nuclear Energy

(a) Fossil Fuel and Newspaper Advertisement, 1986/1-1986/7

Dependent Variable	Log (Advertisement + 1)				
	(1)	(2)	(3)	(4)	(5)
Ad Type	Total Ad	NonJob Ad	Job Ad	FrontPage Ad (1 page)	FrontPage Ad (2 page)
Fossil Fuel × Post Chernobyl	-0.014	-0.106	-0.045	-0.091	-0.113
	(0.068)	(0.066)	(0.098)	(0.058)	(0.074)
N	3500	3500	3500	3500	3500
Month FE	X	X	X	X	X
Company FE	X	X	X	X	X

(b) Fossil Fuel Advertisement and Newspaper Sentiment, 1986/1-1986/7

Dependent Variable	Log (NegativeArticle + 1)				
	(1)	(2)	(3)	(4)	(5)
Ad Type for Ratio	Total Ad	NonJob Ad	Job Ad	FrontPage Ad (1 page)	FrontPage Ad (2 page)
Log(Ratio) × Post Chernobyl	0.358***	0.303**	0.183***	0.158**	0.147**
	(0.115)	(0.125)	(0.057)	(0.060)	(0.073)
Mean of Dep. Var.	2.087	2.087	2.087	2.051	2.069
S.D. of Dep. Var.	1.085	1.085	1.085	1.079	1.084
N	658	658	658	546	623
R2	0.78	0.78	0.78	0.80	0.78
Month FE	X	X	X	X	X
Newspaper FE	X	X	X	X	X

Notes: The standard errors in parentheses are clustered at the company and newspaper levels in the two panels, respectively. * p < 0.1, ** p < 0.05, *** p < 0.01.

Note that a key difference between the media response and legislative response to Chernobyl lies in their time-sensitiveness. In the legislative process, months or even years of extensive research and negotiations are usually needed before a nuclear-related bill can be proposed and eventually voted on, while campaign donations can be made flexibly in any election cycle. As a result, as shown in the previous sections, the impact of Chernobyl on the legislative process unfolded over more than an entire decade, giving fossil fuel firms enough time to adjust their campaign donations accordingly, and also giving congressmen enough time to change their nuclear-related stances after receiving such donations. In stark contrast, as demonstrated in Section 3.1, media response to Chernobyl is much more short-lived. After the accident, major newspapers essentially had a short time window of a few weeks to have extensive coverage about nuclear energy, after which public interest quickly shifts to other issues. Given such time-sensitive nature of intensive media coverage on nuclear, there is limited room for fossil fuel firms to systematically "purchase" additional anti-nuclear coverage by suddenly spending more on advertisements after Chernobyl. This is confirmed by Table 5a, which shows that fossil fuel companies did not significantly increase their advertisement spendings following the Chernobyl accident.

While it is challenging for fossil fuel companies to exert substantial influence on newspapers in the

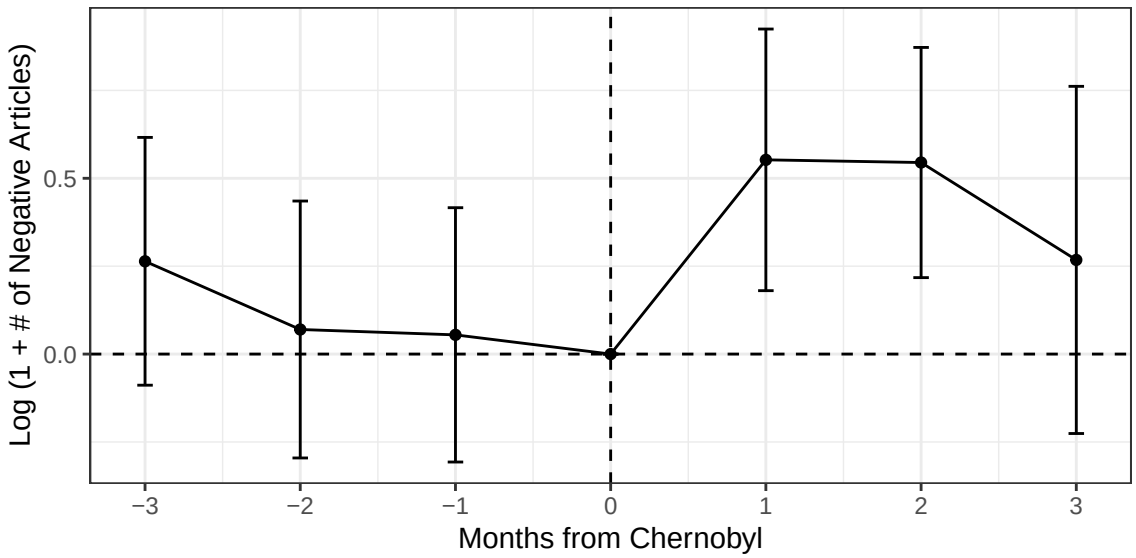


Figure 6: Fossil Fuel Advertisements and Negative Nuclear Coverage in US Newspapers

short run by suddenly purchasing more advertisements, they can potentially leverage their long-term advertisement spending to pressure the corresponding newspapers, a common practice in the media industry, as suggested by Soley and Craig (1992). This logic is similar to that of the aforementioned findings on how congressmen from fossil fuel intensive states, despite not receiving differentially higher campaign contributions from fossil fuel companies after Chernobyl, still became more anti-nuclear in congressional votings. Therefore, we examine on how pre-existing fossil fuel advertisements, which proxy for the importance of the fossil fuel industry for a newspaper's long-run profitability, affect that newspaper's post-Chernobyl reporting about nuclear energy. Specifically, to investigate whether newspapers with stronger pre-existing ties to fossil fuel companies became more anti-nuclear after Chernobyl, we estimate the following event study specification:

$$Log(1 + Negative_{it}) = \sum_{k \neq -1} \beta_k FossilAd_i \times \mathbb{1}\{t = k\} + \lambda_i + \gamma_t + \epsilon_{it}. \tag{3}$$

where $Negative_{it}$ is the number of anti-nuclear-energy articles published in newspaper i in month t. $FossilAd_i$ is the log share of fossil fuel advertisements in newspaper i in the six months prior to Chernobyl (relative to advertisements by other Fortune 500 companies). We control for newspaper fixed effects, months fixed effects, and the standard errors are clustered at the newspaper level.

Figure 6 shows that newspapers with more vs. less pre-existing fossil fuel advertisements did not show any differential trends in nuclear energy coverage prior to Chernobyl. However, after Chernobyl,

newspapers with stronger pre-existing fossil fuel ties showed significantly stronger anti-nuclear sentiment in their contents in the following months. As quantified in Table 5b, an 100 percent increase in pre-existing fossil fuel advertisements is associated with a more than 35 percent increase in anti-nuclear newspaper articles, and the effect exists for both job and non-job advertisements. This alleviates the concern that this relation might be fossil fuel firms trying to expand after seeing a negative shock to their main competitor. Column (4) suggests that the result is also not entirely driven by front-page advertisements.

Taken together, our findings are consistent with the interpretation that the big fossil fuel companies leveraged their economic influence over U.S. newspapers to foster more anti-nuclear news coverage after the Chernobyl accident.

4 Is the U.S. a Special Case?

In this section, we evaluate to what extent the fossil fuel influence in nuclear regulations documented in post-Chernobyl U.S. is generalizable to other settings.

4.1 Cross Country Evidence

We obtain cross-country data on nuclear development from the Power Reactor Information System (PRIS) from the International Atomic Energy Agency (IAEA). PRIS contains data on a variety of indicators, such as the number of operating reactors by country-year, total capacity of operating reactors by country-year, number and capacity of reactors under construction by country-year, etc. Democracy scores come from Polity IV. Data on reserves, consumption, and production of oil, gas, coal, and biofuels are from the U.S. Energy Information Administration (EIA). We merge these data into a country-year panel with countries that ever built a nuclear power plant. In total, there are 34 such countries, which altogether ever operated 276 NPPs with 630 nuclear reactors.

Figure 7 plots the number of operating nuclear reactors worldwide over time, showing that there is a rapid rise from 1960 to 1985, but the rise flattens out immediately after Chernobyl and remains at the flatter slope in the subsequent decades. Figure 7b plots the *net growth* in the number of operating reactors over time. We fit a polynomial to the data and also plot the 95% confidence interval. There is a sharp, discontinuous drop after the Chernobyl accident.

Next, we show that most of this decline is due to a sharp reduction in the growth of nuclear operating reactors in countries with democratic governments: countries with a 1985 Polity IV score of 8 or higher. In our sample, they are Argentina, Belgium, Canada, Finland, France, Germany, India,

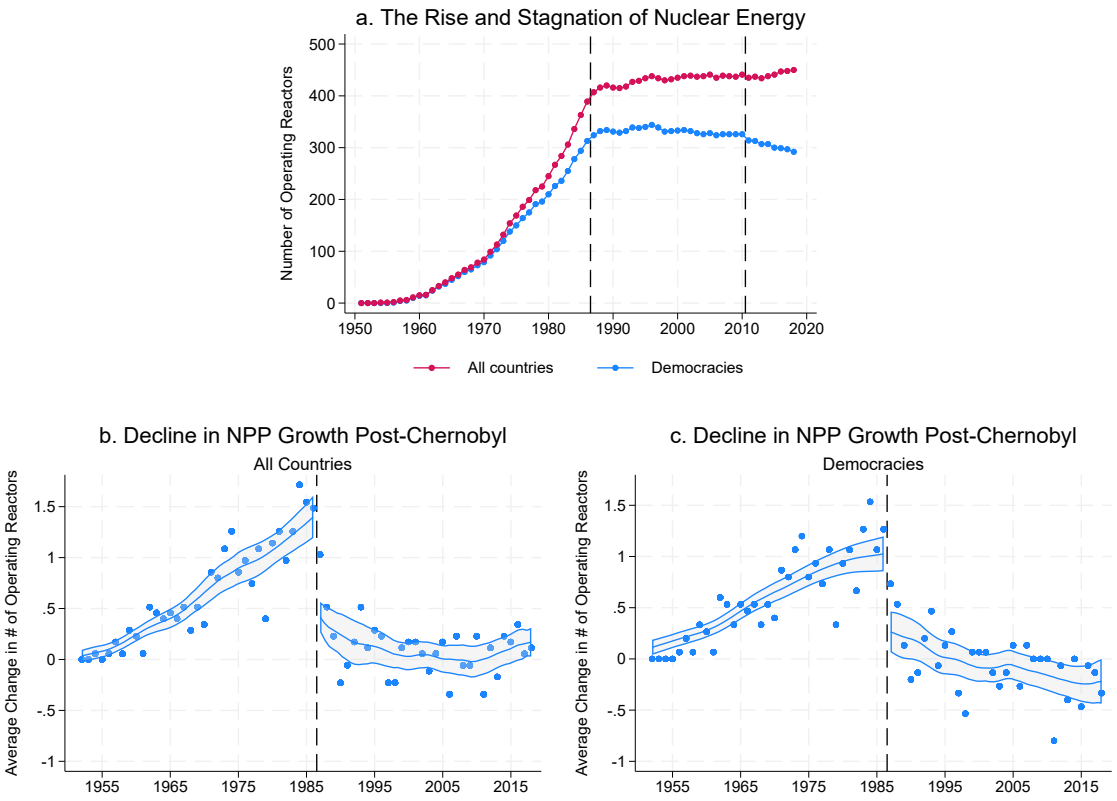


Figure 7: NPP Growth Over Time

Italy, Japan, Netherlands, Spain, Sweden, Switzerland, United Kingdom, and the United States.[11]

Figure 7a plots the number of all NPPs in democracies (in blue) juxtaposed against the number of NPPs worldwide (in red). Throughout the period, democracies hosted the majority of NPPs — 294 out of 363 reactors as of 1985 were in democratic countries. The country that had the most reactors in 1985, 90, was the United States. It was followed by France at 43 and the United Kingdom at 38. Similar to the worldwide patterns, in democratic countries, the number of NPPs was growing at a fast rate during the 1960s, 70s, and early 1980s but after the Chernobyl accident, the NPP growth has halted. Figure 7c shows this more vividly by plotting the annual growth in NPPs for democracies. We fit a polynomial to the data and also plot the 95% confidence interval. The figure shows that prior to Chernobyl, democratic countries experienced high growth in NPP; however, the pace of growth discontinuously declined at the time of the Chernobyl accident. Prior to Chernobyl, the average country built around one NPP per year. After Chernobyl, that number immediately fell to less than one per every other year and later converged to zero.

To assess the statistical significance of these relationships, we estimate the following regression:

$$y_{it} = \beta PostChernobyl_t + \Gamma X_{it} + \gamma_i + \varepsilon_{it} \tag{4}$$

where y_{it} is the growth in the number of nuclear power plants in country i in year t. On the right hand side, we include a dummy variable for "post Chernobyl" and country fixed effects. We will estimate this specification both for all countries and for countries that were democracies as of 1985 and not. Standard errors are clustered at the country level.

Table 6 column (1) presents the estimates for all countries with only country and year fixed effects. Column (2) adds a country's logarithm of GDP per capita from the Maddison Project Database as a control variable to account for the fact that countries with larger economies can better afford to construct NPPs. Alternatively, column (3) adds the country-year linear trends to account for their long-run convergence/divergence in economic development. Across these specifications, the growth in the number of operating nuclear reactors declined sharply by 0.3 to 0.7 fewer operating nuclear reactors per year.

Columns (4)-(6) report similar estimates for democratic countries only, and columns (7)–(9) report the results for the remaining countries in our sample. Columns (5)–(6) and (8)–(9) show that accounting for GDP or country-specific trends, NPP growth declined in all countries after Chernobyl,

[11] Countries in our sample a 1985 Polity IV score below 8 are Armenia, Bangladesh, Belarus, Brazil, Bulgaria, China, Czech Republic, Hungary, Iran, Kazakhstan, South Korea, Lithuania, Mexico, Pakistan, Romania, Russia, Slovakia, Slovenia, South Africa, Taiwan, Turkey, Ukraine, and the UAE.

but the decline was much larger in democracies, which had more reactors and were experiencing higher growth prior to Chernobyl. These estimates also confirm the statistical significance of the decline in NPP growth that was illustrated by the earlier figures.

Table 6: The Impact of Chernobyl on NPP Growth

	Dependent Variable: Yearly Growth in # of Operating Reactors								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All Countries			*Democracies Only*			*Other Countries*		
Dep. Var. Mean	0.206	0.218	0.206	0.304	0.304	0.304	0.129	0.140	0.129
Dep. Var. SD	0.949	0.979	0.949	1.273	1.273	1.273	0.566	0.595	0.566
Post Chernobyl	-0.301**	-0.683***	-0.609***	-0.696***	-1.189***	-1.006***	0.012	-0.277**	-0.295**
	(0.127)	(0.185)	(0.168)	(0.228)	(0.370)	(0.331)	(0.091)	(0.101)	(0.113)
Log GDP per capita		0.456***			0.682**			0.362*	
		(0.161)			(0.242)			(0.187)	
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country-Specific Trends			Y			Y			Y
Obs	2,176	2,035	2,176	960	960	960	1,216	1,075	1,216
Countries	34	34	34	15	15	15	19	19	19
R-squared	0.14	0.17	0.26	0.18	0.20	0.26	0.12	0.19	0.30

Notes: Columns (1)-(3) report the results for all countries that have ever had a nuclear power plant. Columns (4)-(6) report the results for a subset of these countries that had a Polity IV democracy score equal to or above eight out of ten as of 1985. Columns (7)-(9) report the results for the countries with the score below eight. The standard errors in parentheses are clustered at the country level. * p<0.1, ** p<0.05, *** p<0.01.

Motivated by the finding that the post-Chernobyl global decline in nuclear investment is primarily driven by democratic countries, next we zoom into the U.K., another large democracy that was once also a global leader in nuclear energy, and investigate whether similar forces as observed in the U.S. also played a role in shaping its nuclear policies.

4.2 U.K.

The United Kingdom had 38 nuclear reactors in operation in 1985, the third highest number in the world. Nuclear energy was seen as an important alternative to coal, which was in steady and rapid decline in the country. The decline of coal was accompanied by intense political conflict between coal miners' unions and the Conservative government (1970-1997). The National Coal Board advocated for the closure of many mines that were deemed unproductive. The National Union of Miners (NUM), the national organization of local miners' unions, responded with strikes. The strikes were successful in 1972 and 1974, but unsuccessful in 1984-85, where large government stockpiles prepared by the Thatcher-led government (1979-1990) outlasted the eleven-month strike. This was the last large miners strike in the U.K. (Moore and Thatcher, 2013).

Chernobyl took place one year after the 1984-85 strike. Although U.K. coal production had been in steady decline, coal workers and miners' unions still exerted influence. At the end of 1985, a few months before Chernobyl occurred, there were 133 mines that produced 94 million tons and employed

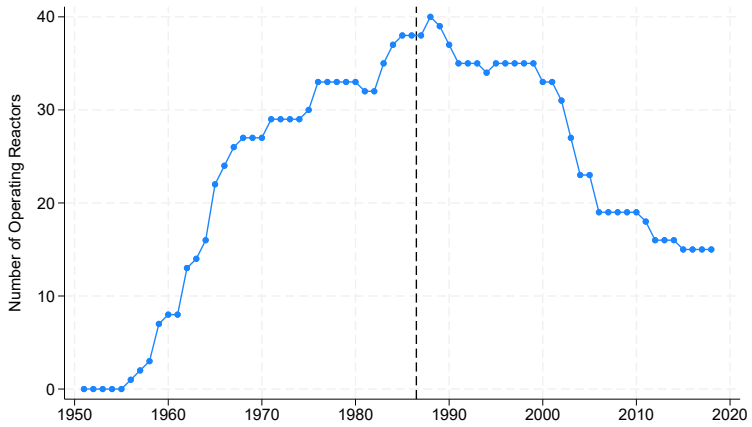


Figure 8: Total Number of Operating Nuclear Reactors in the UK over time

114,000 workers in the U.K. (Department for Energy Security and Net Zero, 2023).

The goal of our analysis is to investigate whether miners' unions took advantage of Chernobyl to lobby against nuclear energy investment.

Figure 8 also plots the number of operating reactors in the UK over time. We observe a steady increase over time that reverted soon after Chernobyl.

4.2.1 Miners Sponsorship and MP Anti-Nuclear Speeches

This section investigates the relationship between an MP's connection to a miner union and his expressed political attitude towards nuclear energy after Chernobyl. If fossil fuel special interests took advantage of Chernobyl to fight against nuclear, then we should see an increase in anti-nuclear sentiment for MPs sponsored by miners' unions relative to other MPs after Chernobyl.

The main outcome measure is the extent to which the MP speaks against nuclear investment in Parliament. We do not examine voting outcomes because Parliament rarely votes on nuclear-related issues during this period. Most decisions are made by a central board, which has broad discretion. We use machine learning methods to identify speeches that are anti-nuclear (32%), neutral (50%) and pro nuclear (18%).[12] We construct a constituency and month-level panel during 1983–1989, three years before and after the Chernobyl accident.

We follow Fouirnaies (2019) and identify whether an MP is sponsored by a miners' union.[13] All

[12] In the U.K., the central regulatory body makes more decisions that the U.S. NRC. Similarly, we do not present estimates for mining sponsorships as an outcome because there is little shuffling across MPs in sponsorships during this period.

[13] We thank Alex Fouirnaies for kindly sharing these datasets with us. 98% of all mining-union-sponsored MPs in our sample were sponsored by either the Miners' Federation of Great Britain or the National Union of Mineworkers.

miner-union-sponsored MPs are in the Labour Party. The Labour Party founding documents gave unions exclusive right to sponsor MP candidates. Such (transparent) sponsorship was unique to the Labour party. Candidates could only be sponsored by one union in a particular election.

Our hypothesis is that miners unions took advantage of Chernobyl to promote their anti-nuclear agenda. To investigate this, we examine the relationship between whether an MP is sponsored by a miners' union and the number of anti-nuclear speeches the MP gives in parliament. Specifically, we estimate the following equation:

$$y_{icmt} = \beta Mining_{ic} \times Post_{mt} + \gamma_{ic} + \lambda_{mt} + \varepsilon_{icmt}, \tag{5}$$

where the number of anti-nuclear speeches by MP i in constituency c in month m and year t, y_{icmt}, is a function of: the interaction of an indicator of whether a mining union sponsored the MP in the previous election cycle, $Mining_{ic}$, and an indicator of whether the speech took place after the Chernobyl accident, $Post_{mt}$; γ_{ic} are the MP-constituency fixed effects and λ_{mt} are the year-month fixed effects. Standard errors are clustered at the MP-constituency level.

Table 7a presents the results. Column (1) examines the number of speeches with anti-nuclear sentiment as the dependent variable. 10% of these speeches mention "Chernobyl." 43% mention "coal." The interaction coefficient is 0.128. It is statistically significant at the 5% level. This is a sizable effect since the mean number of ant-nuclear speeches is 0.021 and the standard deviation is 0.206. In other words, MPs sponsored by miners' unions increase the number of anti-nuclear speeches by around one-half of a standard deviation after Chernobyl.

Column (2) examines the number of speeches that discuss nuclear energy. Column (3) examines the number of speeches that mention "Chernobyl." Column (4) examines the number of anti-nuclear speeches that mention Chernobyl. Column (5) examines the number of anti-nuclear speeches that mention "coal". Column (6) examines the number of anti-nuclear speeches that mention "coal." Column (7) examines the number of speeches that mention "nuclear." We find that the interaction coefficient is positive for all of these outcomes.

Table 7b presents the results of several falsification tests. Column (1) examines the # of speeches that mention "nuclear weapons." Miners' unions were not known to have a strong stance about nuclear weapons, which were an important topic of discussion at the time. Thus, we view this as a falsification test. We find a small and statistically insignificant interaction coefficient. Columns (2)–(5) show that MPs sponsored by miners' unions did not become more worried about health and environment in their speeches more generally. Column (6) also shows no statistically significant differential change in the

Table 7: Chernobyl and U.K. Parliamentary Speeches

(a) Differential Change in Antinuclear Rhetoric by UK MPs Sponsored by a Mining Union.

	(1) # of speeches with anti-nuclear sentiment	(2) # of speeches talking about nuclear energy	(3) # of speeches mentioning Chernobyl	(4) # of antinuclear speeches mentioning Chernobyl	(5) # of speeches mentioning coal	(6) # of antinuclear speeches mentioning coal	(7) # of speeches mentioning "nuclear"
Post-Chernobyl ×	0.128**	0.293**	0.077**	0.078**	0.482*	0.120**	0.270**
Mining-Union Sponsored	(0.059)	(0.135)	(0.032)	(0.032)	(0.253)	(0.060)	(0.115)
Observations	34,727	34,727	34,727	34,727	34,727	34,727	34,727
Year-month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MP-constituency FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dep. Var. Mean	0.021	0.079	0.015	0.003	0.236	0.008	0.204
Dep. Var. SD	0.206	0.516	0.162	0.065	1.083	0.104	0.84

(b) Other Speech Outcomes for UK MPs Sponsored by a Mining Union.

	(1) # of speeches talking about nuclear weapons	(2) # of speeches mentioning hospitals	(3) # of speeches mentioning health	(4) # of speeches mentioning clean water	(5) # of speeches mentioning clean air	(6) Total # of speeches	(7) # of speeches with anti-nuclear sentiment
Post-Chernobyl ×	0.004	-0.049	-0.049	-0.000	0.057	0.479	
Mining-Union Sponsored	(0.014)	(0.042)	(0.064)	(0.001)	(0.043)	(0.316)	
Post-Chernobyl ×							0.003
Sponsored by a Non-Mining Union							(0.009)
Observations	34,727	34,727	34,727	34,727	34,727	34,727	34,727
Year-month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MP-constituency FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dep. Var. Mean	0.067	0.214	0.577	0.002	0.003	1.720	0.021
Dep. Var. SD	0.428	0.807	1.728	0.045	0.080	2.983	0.206

Notes: The sample is restricted to 1983–1989, i.e., three years before and three years after the Chernobyl disaster. Standard errors in parentheses are clustered at the MP level. *** p<0.01, ** p<0.05, * p<0.1.

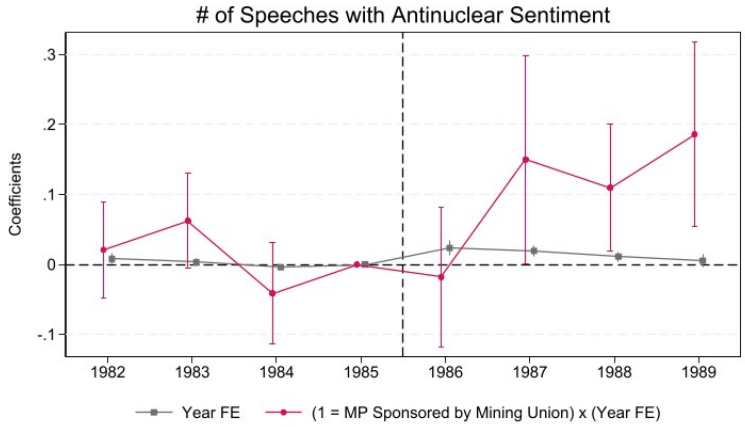


Figure 9: Differential Change in Antinuclear Rhetoric, Event Study

total number of speeches. Finally, Column (7) shows that MPs sponsored by other, non-mining-related, unions did not see a spike in the number of antinuclear speeches post-Chernobyl.

To understand the dynamics of the estimates, we estimate a similar equation to equation 5 except that we replace the interaction with the post-Chernobyl dummy variable with the interactions of miner's union sponsorship and yearly indicators. We also omit the monthly indicators and keep only the yearly dummies for illustration purposes. For brevity, we focus on the number of anti-nuclear speeches. Figure 9 plots the estimates. The coefficients for the yearly dummy variables (in grey), which reflect the number of anti-nuclear speeches from MPs who are not sponsored by miners' unions, show that MPs who are not sponsored by miners' unions increase the number of anti-nuclear speeches slightly after Chernobyl. The interaction coefficients (in red), which reflect the differential number of anti-nuclear speeches by MPs who are sponsored by miners' unions, show that such MPs made a similar number of anti-nuclear speeches as other MPs before Chernobyl and in the few months immediately after the accident. However, starting in 1987, and especially in the run-up to the parliamentary elections held in spring that year, MPs sponsored by miners' unions make significantly more speeches against nuclear energy. The effect is persistent over time.

These results are consistent with our hypothesis that miners' unions used Chernobyl as an opportunity to reduce nuclear energy investment. Unfortunately, as explained earlier, we are unable to further trace voting behavior because the Parliament rarely votes on nuclear-related issues, which are governed by a central board.

5 NPP Safety and Air Pollution

Together, the cross-country and within-country evidence so far supports the hypothesis that fossil fuel interests attempted to leverage the Chernobyl accident to foster a global decline in nuclear investment. Such a decline in new NPPs can affect societal well-being in various ways. An obvious tradeoff created by the decline of NPP construction is about nuclear risk exposure. On the one hand, by reducing the total number of operating reactors, the reduction in nuclear investment can lower total nuclear risk. On the other hand, without constructing new reactors, many countries extend the service of old, earlier-generation reactors with inferior safety records, which could increase nuclear risk in these settings. It is admittedly challenging to quantify the risks associated with extreme nuclear accidents, such as severe reactor meltdowns like that happened in Chernobyl or Fukushima, due to the rarity of such tail events. Instead, in Section 5.1, we investigate the exposure to less extreme nuclear risk, as proxied by the frequency of smaller-scale accidents in day-to-day operations, each of which has a small but non-zero chance of potentially turning into a tail event.

In addition to safety, another frequently discussed impact of nuclear power is to reduce the reliance on fossil fuel, thereby lowering pollution levels and benefiting human health. In Section 5.2, we examine how the construction of NPPs affects satellite-based pollution measures, and use these estimates to conduct back-of-the-envelope calculations on the potential life years lost due to the higher pollution exposures associated with stalled global NPP construction.

5.1 Safety

NPP operators have improved operating procedures to reduce the possibility of reactor meltdowns. Safety has also improved with new technology. Chernobyl, Three-Mile Island and Fukushima were all Generation II reactors constructed in the 1960s and 70s. The first Generation III NPP was built in 1996. Seven Generation III NPPs operate currently in Japan, China, and India. Nuclear scientists are currently research Generation IV NPPs.[14] Experts agree that new power plant designs (Generation III+) are safer (as measured by the probabilistic risk assessments for core damage frequency, CDF)

[14]The Bureau of Labor Statics (BLS) keeps data on both the "Incidence Rates of Nonfatal Occupational Injuries" and fatalities. From 2006 to 2015, the nuclear generation industry is on average 4.7 times safer than hydroelectric power, five times safer than fossil fuel, 6.6 times safer than electric power transmission, and nearly seven times safer than natural gas distribution. For fatalities, the picture is the same. Since 2003, BLS has recorded just one fatality for nuclear power generation, which was unrelated to radiation exposure. There have been 12 fatalities in hydroelectric power, 39 in fossil power, and 184 in electric power distribution. However, this doesn't account for the number of power plants in each respective industry. There are hundreds of fossil fuel power plants and only 61 nuclear plants. Yet, on this count, nuclear still leads the field in safety. Per terawatt hour of electricity generation (equivalent to 1,000 gigawatts), nuclear is still the safest: 2.9 times safer than hydroelectric, 128 times safer than solar, and 131 times safer than fossil fuel power generation (Batkins et al., 2017).

by many orders of magnitude. Generation III reactors have been improved to have lower core damage frequencies (3 to 60 events per 100 million reactor-years versus 1,000 events per 100 million reactor years). They address the problems from past accidents by including passive safety features that do not require active controls or operator intervention but instead rely on gravity or natural convection to mitigate the impact of abnormal events. For comparison, note that Gen III AP1000 designs, which is popular in South Korea and have been adopted by the U.S. in Georgia, have a 1/60 million chance of CDF in a year, which exceeds U.S. Nuclear Regulatory Commission (NRC) requirements by a factor of 6,061. In contrast, older Gen II plants, which constitute all other currently operating plants in the U.S. today have a 1/20000 CDF per year, and is two times safer than NRC requirements.[15]

In this section, we first verify whether the younger and newer-generation reactors are indeed safer. And to the extent they are, we examine how the global reduction in NPP construction might result in higher average nuclear risk per reactor, while lowering total nuclear risk for all reactors.

Specifically, Wheatley, Sovacool and Sornette (2017) compiles a comprehensive dataset on the universe of incidents and accidents that had material relevance to safety, caused property damage, or resulted in human harm between 1950 and 2014.[16] We use Poisson regressions to estimate the relationship between accidents and the age/generation of the reactor. Then, we use the estimates and data on reactor age and model generation to predict risk over time for all NPPs that have ever operated in the world. As shown in Figure 10a, predicted risk is increasing in a convex manner with respect to age, and is significantly higher for older generation plants at any given age.

Leveraging the estimates in Figure 10a, Figure 10b plots the predicted risk for an average NPP over time. The global average NPP risk increases sharply since the early 1990s, which reflects the fact that the global decline in NPP development after Chernobyl contributed to the aging of existing NPPs worldwide. The faster increase in average NPP risk in democracies is consistent with our cross-country results on NPP development: after the Chernobyl, the democracies, not constructing new NPPs while still facing increases in energy demand, had to delay the retirement of old, early-generation NPPs, which exposes them to substantially higher average NPP risk compared to their authoritarian counterparts, who built new, third-generation NPPs that are much safer. For the U.S. and the U.K., we observe patterns broadly similar to that for all democracies, with the U.K. experiencing a decline of nuclear risk in the 1990s and 2000s due to its mass closure of old-aged NPPs around that time.

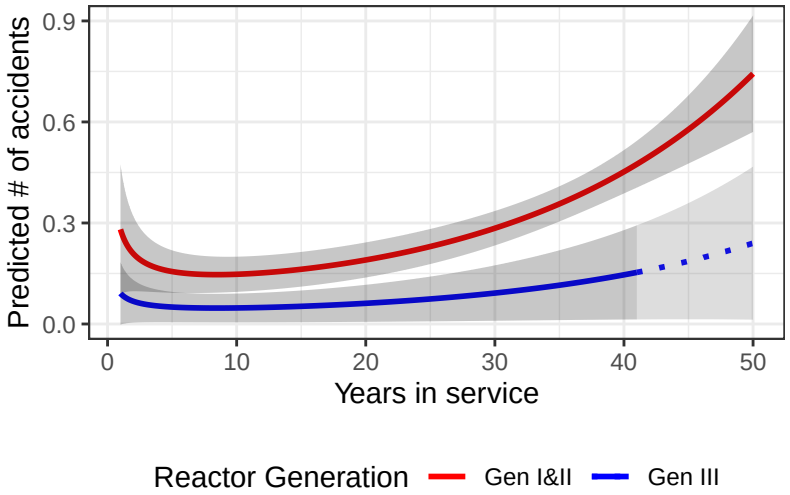
[15] See Batkins et al. (2017).

[16] To be included in the sample, a nuclear accident needs to appear in a published source, such as peer-reviewed academic literature, press releases, project documents, public utility commission filings, reports, and newspaper articles.

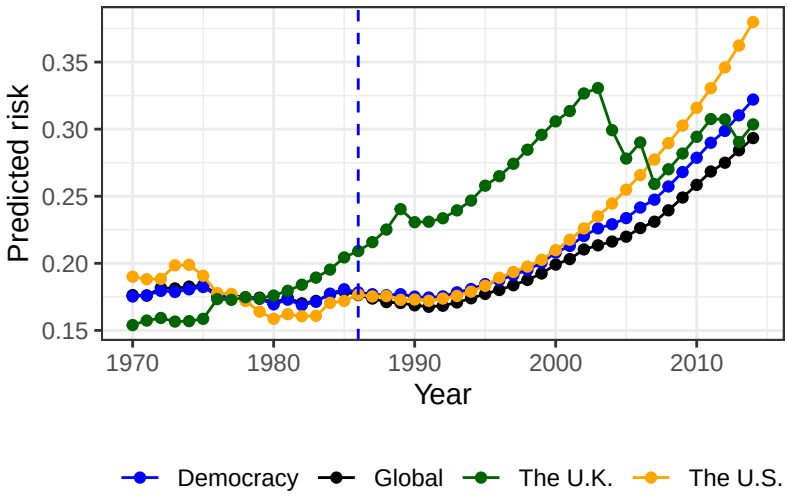
In Figure 10c, we predict the aggregate, instead of average, nuclear risks associated with operating nuclear reactors. The trend in aggregate nuclear risk is ex ante ambiguous, as the global decline in nuclear investment creates two countervailing forces: fewer operating reactors tends to reduce overall risk, while the older age of average operating reactor tends to increase risk levels. As can be seen in Figure 10c, for the world as a whole, the democratic countries, as well as the U.S., the second force more than offsets the first one, leading to an increase in overall nuclear risk exposure over the past four decades. One might find irony in the fact that, the democratic countries, by stalling nuclear investment supposedly out of concerns regarding nuclear risk, actually end up exposing themselves to even more nuclear risks. The U.K. is a notable exception after the 2000s — by closing a large amount of old NPPs, overall nuclear risk decreased in the country over the past two decades.

To quantify these graphical patterns, Appendix Table A.6 re-estimates the cross-country regressions with NPP reactor age, reactor generation and predicted risk as the dependent variables. Columns (1)-(3) confirm that, after the Chernobyl accident, democracies started having older, earlier-generation, and riskier NPPs relative to their non-democratic counterparts. Column (4) suggests that aggregated nuclear risk exposure more than doubled in the democracies (relative to the autocracies) following the Chernobyl accident, which is despite the fact that the democratic countries significantly reduced their total number of operating NPPs over the past four decades while their non-democratic counterparts have resumed NPP construction since the 1990s.

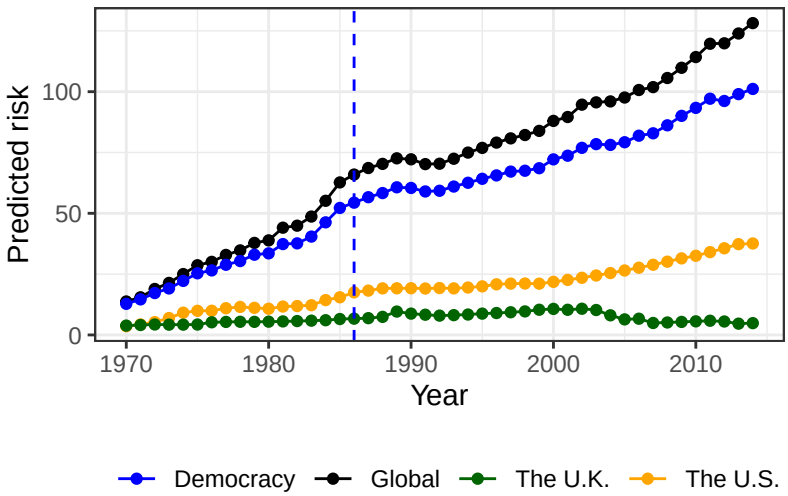
Taken together, the estimates are consistent with the narrative that the slowdown of new NPP construction promoted the use of older plants and delayed the adoption of newer safer plants, which in turn leads to sharp increases in average and aggregate nuclear risk exposures, especially in the democratic countries that experienced sharpest stalls in nuclear investment. Note that we do not take into account the specific reactor model type in this analysis. Our analysis captures the main safety improvements, which are between generations, but we do not measure differences across models within the same generation. This is because differences in models within the same generation are often country-specific (e.g., only Soviet and Soviet-allied countries used the RBMK reactor, one of many generation II models) and the accident data are believed to be comprehensive and representative for countries with democratic governments, but under-reported by other countries (Wheatley et al., 2017).



(a) Age and NPP Accidents



(b) Average Predicted Risk for NPPs



(c) Total Predicted Risk for NPPs

Figure 10: NPP Accidents and Predicted Risk

5.2 Air Quality

One of the main supposed benefits of nuclear energy relative to fossil fuels is that it produces little ambient air pollution while operating.[17] This section attempts to quantify the effect of the slowdown in nuclear energy development after Chernobyl on emissions and health.

Our main measure of air pollution is Aerosol Optical Depth (AOD), which reflects the amount of solid and liquid particles suspended in the atmosphere, and is commonly used as an omnibus proxy for air quality. AOD is measured based on satellite images, since the particles in air change the way the atmosphere reflects and absorbs visible and infrared light. We obtain our AOD data from NASA's Terra satellite with Moderate Resolution Imaging Spectroradiometer (MODIS).[18] The data provide information on the monthly average AOD for all 1 x 1 degree grids worldwide, from 2001 to 2020.[19]

To understand the impact of nuclear reactors on air pollution, we study how the operation of new reactors affects the average AOD of the corresponding metropolitan area. The relationship can be characterized as the following:

$$y_{it} = \beta \#Reactors_{it} + \Gamma X_{i,t-1} + \gamma_i + \delta_t + \varepsilon_{it} \tag{6}$$

where y_{it} is the AOD in the city i in year t; $\#Reactors_{it}$ stands for the number of operating nuclear reactors adjacent to city i in year t;[20] $X_{i,t-1}$ is a vector of covariates for city$i$, such as lagged population and nighttime lights; γ_i and δ_t are NPP and year fixed effects. We define an NPP as operational when at least one reactor is turned on. The standard errors are clustered at the NPP level.

Table 8 Column (1) shows that following the operation of a new reactor, a city's AOD falls by more than 29 units, which is more than 10% of a reduction from the baseline mean. Column (2) shows that the estimates are robust to controlling for the mean and range of yearly temperature, as well as the specific dynamics of country, latitude, border, coast, and reserves for other energy sources.[21] In Columns (3) to (5), we omit China, the U.S., and Russia respectively, and the main effect remains, confirming the robustness of our findings.

[17] Mining and refining uranium ore, creating reactor fuel, the construction of the NPP, and the disposal of spent rods can create pollution and/or carbon dioxide.

[18] For more details, see Platnick, King, Meyer, Wind, Amarasinghe, Marchant, Arnold, Zhang, Hubanks and et al. (2015).

[19] While there exists new satellite-based data product (i.e., MEERA-2) that can further date back to the 1980s, we use the MODIS data in the baseline analysis for two main reasons. First, recent studies benchmarking satellite-based AOD data against ground monitoring data suggest that MODIS significantly outperforms MEERA-2 in terms of the mean of coefficient of determination, mean absolute error, and relative root mean square deviation (Aldabash, Bektas Balcik and Glantz, 2020). Second, the existing studies converting AOD to PM2.5 have focused exclusively on the post-2000 period, which makes it difficult for us to leverage the pre-2000 data for potential back of the envelope calculations.

[20] We define a reactor as being adjacent to cities within its 200-km radius circle, but our findings are robust to using alternative ranges.

[21] Appendix Table A.7 lists the definitions and sources of all the variables used in this analysis.

Table 8: NPP Operation and City AOD

	Dependent Variable: AOD				
	(1)	(2)	(3)	(4)	(5)
NPP Operation	-29.463***	-28.643***	-26.758**	-28.697***	-28.453***
	(6.777)	(6.731)	(12.496)	(6.735)	(6.724)
Other Energy DPI × Year FE		Y	Y	Y	Y
Lagged Population/Nighttime Lights		Y	Y	Y	Y
(Latitude,Border,Coast) × Year FE		Y	Y	Y	Y
Mean Temperature, Temperature Range		Y	Y	Y	Y
Unit FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Dep. Var. Mean	259.394	259.394	259.941	263.549	269.364
Dep. Var. SD	111.484	111.484	111.545	116.775	116.349
R2	0.92	0.92	0.92	0.93	0.92
Sample	all	all	drop China	drop Russia	drop US
Observations	350748	350748	345188	309390	296395

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

One concern may be that new reactors are built near the cities that are already experiencing a decline in pollution because these are the places that are more motivated to phase out fossil fuels. To investigate this hypothesis about pre-trend, we define an NPP as operational based on the activation of its first reactor, and estimate the dynamic effects of activating NPPs on AOD using an event study specification, with adjustments following Sun and Abraham (2021a) to account for heterogeneous treatment effects. Figure 11 plots the dynamic coefficients. We observe no pre-trend in AOD prior to the activation of an NPP, and a distinct decline in AOD after the NPP starts operating. AOD continues to decline for several years afterwards. Since the start year of an NPP is defined by the first year that at least one reactor started working, the downward-sloping trend in the post-operation period could reflect the fact that new NPPs are gradually increasing the reactor's operating capacity and/or gradually launching new reactors over time, which would increasingly replace fossil fuels in the surrounding regions.

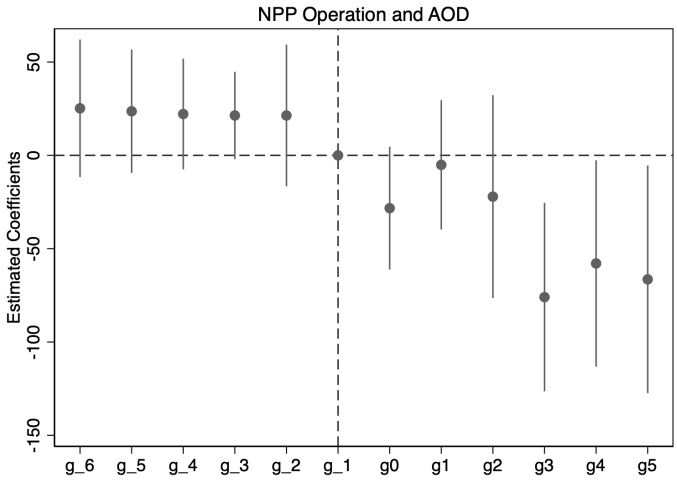


Figure 11: Event Study Estimates: NPP and Ambient Air Pollution

Back of the Envelope Calculations We use the estimate in Table 8 column (2) to calculate the potential aggregate health impacts caused by the Chernobyl-induced slow down of the nuclear reactor construction. The calculation involves four main steps. First, following Kumar, Chu and Foster (2007), we convert our estimated reactor-AOD relationship into a reactor-PM2.5 relationship.[22] Second, following the estimates provided by the Air Quality Life Index (AQLI), we convert the estimated PM2.5 reductions to the potential increases in life expectancies in each region (Energy Policy Institute at the University of Chicago, 2018). Third, linking the estimated gains in life expectancies to the population of cities adjacent to NPPs, we calculate the average life years saved due the activation of an additional nuclear reactor. Fourth, we apply our estimates to the counterfactual number of reactors that could have been built in the United States (or the world) absent the Chernobyl disaster and the political economy dynamics that followed.[23]

According to our calculations from steps one through three, the construction of an additional nuclear reactor, by reducing the total suspended particles (TSP) in the ambient environment, could on average save 0.37 years for each person living nearby. Next, we take three potential scenarios of counterfactual growth in the number of operating nuclear reactors after Chernobyl: (i) assuming that the growth rate remains the same that the US (or the world) had in 1975–1985, (ii) assuming that the

[22] We could also first convert AOD into PM2.5 and then conduct the DiD estimation. This introduces more noise for the regressions, but our main findings remain. These alternative results and the corresponding calculations are available upon request.

[23] Here we are assuming that the reactors that were not constructed due to Chernobyl would have been located in regions at least as populated as the existing reactor locations, and that the reactors would be equally effective in replacing fossil fuel in these regions.

growth rate becomes identical as the growth rate in South Korea, and (iii) assuming that the growth rate becomes identical as the growth rate in Japan. The first counterfactual provides some insight into what might have happened in the absence of Chernobyl disaster while the latter two counterfactuals inform us of what would have happened if Chernobyl took place but without the fossil-fuel-related political economy dynamics, as both South Korea and Japan relied heavily on the imports of fossil fuels. South Korea serves as a liberal benchmark while Japan serves as a conservative one. According to our calculations, if the number of operating nuclear reactors in the US has been growing following the path of Japan, South Korea, or its own growth in 1975–1985, it would have had 52, 208, or 237, respectively, more operating nuclear reactors by 2010, the last year before the Fukushima accident. Taking the average population of the nearest metropolitan area to each nuclear power plant in the United States as 2,003,224, we obtain that from 38 million to 175 million life years have been lost in the US due to the slowdown of nuclear development after Chernobyl. Similar calculations yield 103 million to 1,187 million life years lost in the world due to the slowdown of nuclear development post-Chernobyl.

To evaluate the robustness of our calculations, we also conduct a different version of calculation following Jha and Nauze (2022), which relies on different assumptions and utilizes different estimates in the existing literature. Specifically, we link the estimated reactor-induced changes in pollution levels to the parameter and functional form relating pollution levels to mortality as reported in Beelen, Raaschou-Nielsen, Stafoggia, Andersen, Weinmayr, Hoffmann, Wolf, Samoli, Fischer, Nieuwenhuijsen et al. (2014). Combining that with country-level mortality data and grid-level population data, we obtain the estimated number of premature deaths from pollution exposure due to the slowdown of nuclear reactor construction. These estimates, which take into account the non-linearities in how mortality responds to pollution reduction, again suggest tremendous health consequences of stalled nuclear development. Specifically, our calculations suggest that our three counterfactuals are associated with 41,600 to 189,700 pollution-caused premature deaths avoided in 2010 in the United States and with 112,000 to 1,282,400 pollution-caused premature deaths avoided in 2010 in the world.

Our calculations are likely conservative for several reasons. First, by focusing on cities within 200-km radius circles around each nuclear reactor, we fail to take into account farther away cities that can also benefit from nuclear energy. Such exclusion would create a downward bias in the calculations for regions that have long transmission lines and integrated grids. Second, our average treatment effect of nuclear reactor on pollution is estimated for the sample of regions that ever constructed reactors,

which tend to be economically more developed and environmentally less polluted, where cleaner fossil fuel and more effective abatement facilities are usually employed. As a result, when extrapolating these estimates to the rest of the world, we fail to account for the possibility that a reactor constructed in less developed and more polluting regions can lead to even larger reductions in pollution. Third, our average treatment effect of nuclear reactor on pollution is estimated for the sample period of 2000-2020, when the alternative to nuclear energy also includes renewable energy, instead of just fossil fuel. This would imply that the treatment effect after 2000 might be smaller than that in the previous decades. Fourth, we are taking as given the realized path for nuclear technology development. To the extent that uninterrupted global nuclear investment after 1986 might have greatly reduced the cost and increased the efficiency of nuclear power, these additional benefits are not accounted for in our calculations.

Given these possible caveats, the calculations in this section should not be interpreted literally. We provide them only to illustrate the point that in the counterfactual world where NPPs continued to grow, either at the same rate as before Chernobyl or at some other reasonable rates such as that observed in Korea, air pollution would have likely been much lower, which in turn, would have had significant health benefits.

6 Conclusion

In the post-WWII era, nuclear energy promised to be a source of affordable and clean energy. But investment and enthusiasm fell precipitously after the Chernobyl reactor meltdown. This study provides novel evidence that the political economic interests of fossil fuel interests played a role in the decline. In the U.S., we show that the fossil fuel industry leveraged the Chernobyl accident to lobbying for more anti-nuclear policies in congress, and managed to influence votes in those pivotal and high-stakes bills; in addition, newspapers with stronger pre-existing ties to fossil fuel also published more anti-nuclear articles after Chernobyl. In the U.K, miners' unions also took advantage of Chernobyl to have their representatives giving more anti-nuclear speeches in parliament.

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Figure A.1: Map of Nuclear Reactors in the World, 1985

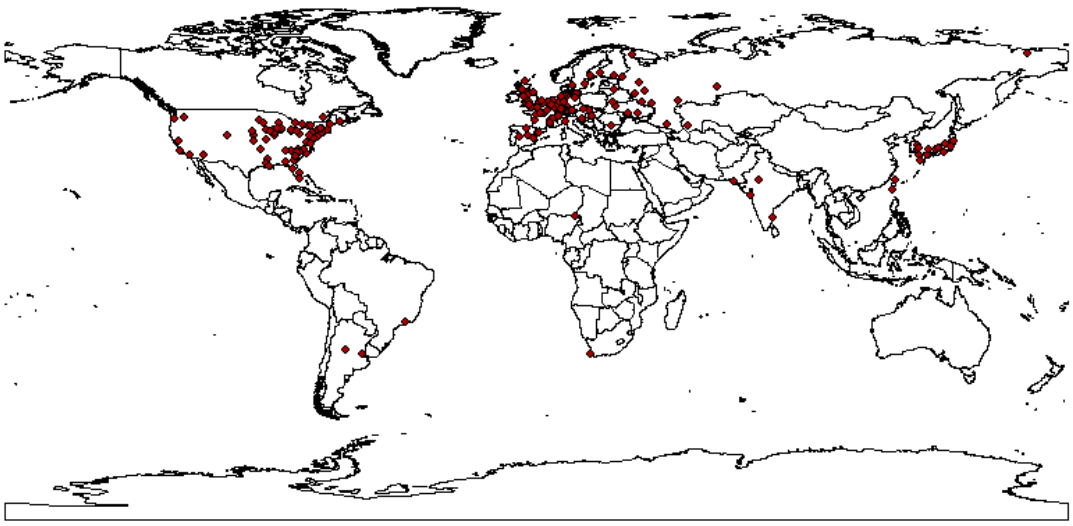


Figure A.2: Map of Nuclear Reactors in the World, 2020

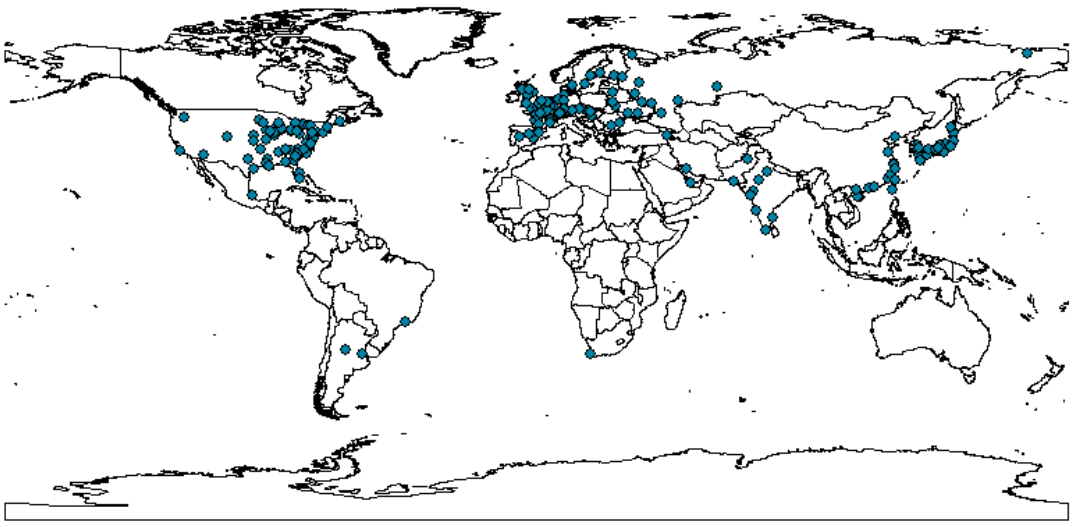


Table A.1: List of All Countries that Ever Built a NPP with Their Democracy Scores in 1985

Country	Polity IV Democracy Score in 1985
Argentina	8
Armenia	0
Belgium	10
Brazil	7
Bulgaria	0
Canada	10
China	0
Czech Republic	0
Finland	10
France	8
Germany	10
Hungary	0
India	8
Iran, Islamic Rep.	0
Italy	10
Japan	10
Kazakhstan	0
Korea, Rep.	0
Lithuania	0
Mexico	1
Netherlands	10
Pakistan	0
Romania	0
Russian Federation	0
Slovak Republic	0
Slovenia	1
South Africa	7
Spain	10
Sweden	10
Switzerland	10
Taiwan	0
United Kingdom	10
Ukraine	0
United States	10

Table A.2: List of Nuclear-Related Congressional Bills by Stakes

Table: Policy topics

Topics	Number of bills	Stakes
international nuclear agreements	15	high
appropriations for (nuclear and nonnuclear) energy research programs	13	high
construction, licensing and shutdown of nuclear power plants and reactors	7	high
supply of nuclear fuel	2	high
nuclear waste management	28	low
export control of nuclear goods and technology	9	low
nomination of members for NRC and other nuclear departments	9	low
authorization act for NRC	7	low
nuclear proliferation prevention	7	low
safety regulations of nuclear material and facilities	4	low
management of nonnuclear energy	3	low
Chernobyl nuclear disaster commemoration	2	low
response to nuclear emergencies	2	low
compensation for victims of nuclear accident	1	low
reorganization of nuclear departments	1	low

Table A.3: Fossil Fuel Donations and Membership on Energy-related Committees, 1979-1996

Dependent Variable	Being on energy-related committees	
	(1)	(2)
Fossil Donation (in 100k USD)	0.036	-0.124*
	(0.065)	(0.064)
Post Chernobyl	0.089	0.117*
× Fossil Donation (in 100k USD)	(0.065)	(0.067)
N	4406	4406
R-squared	0.08	0.71
Cycle FE	X	X
Congressman FE		X
State FE	X	

Notes: The standard errors in parentheses are clustered at the congressman level. * p < 0.1, ** p < 0.05, *** p < 0.01

Table A.4: State-level Fossil Fuel GDP Share and Congressman-bill Level Votes on Important Nuclear Bills, 1979-1996

Dependent Variable	Pro-nuclear vote (1)	Anti-nuclear vote (2)	Absent from voting (3)	Pro-nuclear vote (4)	Anti-nuclear vote (5)	Absent from voting (6)
Post Chernobyl	-0.134	-0.084	0.215	-0.172	-0.096	0.266*
× State-level Fossil Fuel GDP Share	(0.088)	(0.089)	(0.148)	(0.111)	(0.072)	(0.145)
State-level Fossil Fuel GDP Share	0.304	0.205	-0.509***			
× High-stake Bill	(0.187)	(0.235)	(0.175)			
Post Chernobyl	-0.623***	-0.171	0.799***			
× State-level Fossil Fuel GDP Share	(0.232)	(0.253)	(0.152)			
× High-stake Bill						
State-level Fossil Fuel GDP Share				-0.242**	-0.026	0.269
× Pivotal bill				(0.098)	(0.128)	(0.173)
Post Chernobyl				-0.143	0.000	0.143
× State-level Fossil Fuel GDP Share				(0.174)	(0.126)	(0.170)
× Pivotal bill						
Pre-period Dep. Var. Mean	0.315	0.127	0.556	0.315	0.127	0.556
Post-period Dep. Var. Mean	0.421	0.040	0.539	0.421	0.040	0.539
N	17958	17958	17958	17958	17958	17958
R-squared	0.42	0.18	0.36	0.42	0.18	0.36
Cycle FE	X	X	X	X	X	X
Congressman FE	X	X	X	X	X	X
Bill FE	X	X	X	X	X	X

Notes: The standard errors in parentheses are clustered at the state level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.5: State-level Fossil Fuel GDP Share and Donations, 1979-1996

Dependent Variable	Log (Donation + 1)	Log (Donation)	Any Donation
	(1)	(2)	(3)
Post Chernobyl	-0.765	-0.994	-0.130
× State-level Fossil Fuel GDP Share	(1.474)	(0.642)	(0.155)
Mean of Dep. Var.	7.060	8.651	0.814
S.D. of Dep. Var.	3.613	1.492	0.389
N	4386	3579	4396
R-squared	0.57	0.66	0.51
Cycle FE	X	X	X
Congressman FE	X	X	X

Notes: The standard errors in parentheses are clustered at the congressman level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Chernobyl and average reactor age, reactor generation and predicted risk

Dependent Variable	Reactor age	Generation	Average predicted risk	Total predicted risk
	(1)	(2)	(3)	(4)
Post Chernobyl × Democracy	3.750**	-0.656***	0.053**	5.618**
	(1.587)	(0.215)	(0.025)	(2.578)
Mean of Dep. Var.	10.450	1.249	0.196	2.453
S.D. of Dep. Var.	11.254	0.942	0.055	4.411
N	2210	2210	1329	1329
R2	0.93	0.79	0.67	0.81
Year FE	X	X	X	X
Country FE	X	X	X	X

Notes: The standard errors in parentheses are clustered at the country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.7: List of Variables Used in Pollution Regressions

Variable	Description	Source
AOD	Aerosol Optical Depth Land Mean from product MOD08_M3 (2001-2020)	https://ladsweb.modaps.eosdis.nasa.gov/missions-and-measurements/products/MOD08_M3
SO2	Total Column Amount SO2 from product OMSO2e (2005-2020)	https://disc.gsfc.nasa.gov/datasets/OMSO2e_003/summary
Coal Power Units	Units (>30MW) from coal power plants around the world	https://globalenergymonitor.org/projects/global-coal-plant-tracker/tracker/
NPP Oper	Becomes 1 when nuclear reactors operate on the site	https://en.wikipedia.org/wiki/List_of_commercial_nuclear_reactors
LST mean	Land Surface Temperature day mean from product MOD11C3 , monthly data (2001-2020)	https://lpdaac.usgs.gov/products/mod11c3v006/
LST range	Range of monthly LST day mean from product MOD11C3 (2001-2020)	https://lpdaac.usgs.gov/products/mod11c3v006/
LST diurnal range	Average day and night difference of the monthly LST from product MOD11C3 (2001-2020)	https://lpdaac.usgs.gov/products/mod11c3v006/
Border	Whether the city is on the border of its country	
Coast	Whether it's a coastal city	
NTL	harmonized global nighttime light (1992-2020)	https://www.nature.com/articles/s41597-020-0510-y#Sec8
Population density	UN WPP-Adjusted Population Density (2000, 2005, 2010, 2015, 2020), interpolated	https://sedac.ciesin.columbia.edu/data/set/gpw-v4-population-density-adjusted-to-2015-unwpp-country-totals-rev11
Hydropower	Global Development Potential Indices for hydropower (2016)	https://sedac.ciesin.columbia.edu/data/set/lulc-development-potential-indices/data-download
Concentrated Solar Power	Global Development Potential Indices for concentrated solar power (2016)	https://sedac.ciesin.columbia.edu/data/set/lulc-development-potential-indices/data-download
Photovoltaic Solar Power	Global Development Potential Indices for photovoltaic solar power (2016)	https://sedac.ciesin.columbia.edu/data/set/lulc-development-potential-indices/data-download
Oil	Global Development Potential Indices for oil (2016)	https://sedac.ciesin.columbia.edu/data/set/lulc-development-potential-indices/data-download
Gas	Global Development Potential Indices for gas (2016)	https://sedac.ciesin.columbia.edu/data/set/lulc-development-potential-indices/data-download
Coal	Global Development Potential Indices for coal (2016)	https://sedac.ciesin.columbia.edu/data/set/lulc-development-potential-indices/data-download
Wind	Global Development Potential Indices for wind (2016)	https://sedac.ciesin.columbia.edu/data/set/lulc-development-potential-indices/data-download

A Example of Pro-nuclear and Anti-nuclear Bills

The Nuclear Safety, Research, Demonstration, and Development Act of 1980 (H.R.7865), introduced during the 96th Congress (1979–1980), is an example for pro-nuclear bills. This bill focused on advancing nuclear technology and safety measures. It authorized federal funding and collaborative efforts to support research and development in nuclear energy, demonstrating a commitment to enhancing nuclear power's role in the energy mix. The bill also addressed technological innovation and public-private partnerships to strengthen the nuclear industry's infrastructure.

Conversely, the Nuclear Waste Policy Act (H.R. 8378), introduced during the 96th Congress (1979–1980), exemplifies anti-nuclear concerns, particularly regarding the long-term management of nuclear waste. This bill proposed the establishment of licensed permanent repositories for high-level radioactive waste, spent nuclear fuel, and transuranic waste. Additionally, it authorized the formation of state compacts to manage regional repositories for low-level radioactive waste. While addressing critical safety and environmental issues, the bill reflected growing skepticism about the viability of nuclear energy, emphasizing the unresolved challenges associated with waste disposal and the associated risks to public health and the environment.

B U.S. Campaign Contributions from Fossil Fuel Firms

Our U.S. the Database on Ideology, Money in Politics, and Elections (DIME), ranging from 1979 to 2014. From this dataset, we retrieved all contributors based on a comprehensive list of energy companies. For every firm that made at least one campaign contribution in DIME, we search its profile and manually classify whether its primary business lies in the fossil fuel industry. We end up with 381 firms in the fossil fuel industry that ever made contributions. The final database contains fossil fuel firms that have made at least one contribution during our sample period. Firms in the list were manually checked for accuracy. For every donation made to a congressman, we know the donor, the recipient, the timing of the donation, and its amount.