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The electoral consequences of environmental accidents: Evidence from Chernobyl

Adrian Mehic [*,1]

Research Institute of Industrial Economics (IFN), Box 55665, 102 15 Stockholm, Sweden
Department of Economics, Lund University, Tycho Brahes väg 1, 223 63, Lund, Sweden

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ABSTRACT

This paper examines the relationship between environmental accidents and voting. Following the 1986 Chernobyl disaster, environmentalist parties entered parliaments in several nations. This paper uses Chernobyl as a natural experiment creating variation in radioactive fallout exposure over Sweden. I match municipality-level data on cesium ground contamination with election results for the environmentalist Green Party, which was elected to parliament in 1988. After adjusting for pre-Chernobyl views on nuclear power, the results show that voters in high-fallout areas were more likely to vote for the Greens. Detailed individual-level survey data suggests that resistance to nuclear energy increased in fallout-effected areas after the accident, and that this change was driven by voters who followed local media closely.

1. Introduction

One of the major trends in Western politics in recent years is the growth of green parties. At the same time, amid climate change, environmental accidents and natural disasters have become more common. What is the relationship between environmental accidents and political outcomes? Previous findings suggest that wildfire exposure increases voter support for pro-environmental measures, and unexpected temperature fluctuations increase voter concerns about climate change (Egan and Mullin, 2012; Herrnstadt and Muehlegger, 2014; Hazlett and Mildenberger, 2020). Still, there is relatively little previous research on this subject.

In this article, I use the natural experiment generated by the most disastrous environmental disaster in modern history, the 1986 Chernobyl nuclear disaster, to evaluate the impacts on voting outcomes. More specifically, I use between-municipality variation in radioactive fallout over Sweden caused by Chernobyl in order to examine the causal effect of exposure to fallout on voting, focusing on votes for the Green Party (*Miljöpartiet*, MP), which was elected into parliament in 1988, two years after the incident. The rise of the MP mirrors a similar development in other Western nations in the years following Chernobyl. For the identification strategy, I use an important property of radiation deposition, namely that virtually all of the Chernobyl releases were spread though rainfall (Clark and Smith, 1988). Hence, due to differences in precipitation levels, there were large variations between municipalities in terms of concentrations of fallout. Immediately after the reactor fire at Chernobyl was extinguished, authorities conducted large-scale aerial measurements of radioactive fallout in each municipality.

Controlling for other factors, the results suggest that the increase in the Green Party vote share in the 1988 elections was higher in municipalities with higher fallout levels. The positive impact on the green vote was particularly noticeable in municipalities with very high levels of fallout exposure. The Chernobyl effect on the green vote remained positive for most of the subsequent election years after 1988.

To evaluate the mechanisms behind the changes in the green vote, I use the results from an annual, nationwide survey, where the respondents are selected randomly, matched with data on fallout levels in respondents' home municipalities. Comparing with pre-1986 attitudes to nuclear power, I find that there was significantly lower support for nuclear power in fallout-affected areas immediately after the accident. However, beginning already in the late 1980s, this fallout-driven heterogeneity in attitudes towards nuclear power began gradually eroding, a finding consistent with the voting results. In addition, the survey results show that the negative attitudes toward nuclear

* Department of Economics, Lund University, Tycho Brahes väg 1, 223 63, Lund, Sweden.
E-mail address: adrian.mehic@nek.lu.se.

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power in contaminated municipalities in the years immediately following the accident were primarily a consequence of fears of higher cancer incidence and deteriorated local environments, rather than concerns about the risk of nuclear accidents. Additionally, pro-environmentalist sentiments were considerably more pronounced among individuals who frequently read local newspapers. This finding is consistent with previous research showing that media exposure, particularly local as opposed to national media, can significantly alter voter preferences (Gentzkow, 2006; Enikolopov et al., 2011; Kendall et al., 2015; Repetto, 2018).

It is common that the growth of new political movements leads to significant policy changes (Tabellini, 2019). The election of the Green Party into parliament was no exception. For instance, it contributed to a 1990 decision of the Social Democratic government to implement a carbon tax, one of the first of its kind in the world (Hildingsson and Knaggård, 2022). After implementation of the tax, carbon dioxide emissions from transport declined by around 11% (Andersson, 2019). However, the success of environmentalist parties in the late 1980s was not limited to Sweden. In several European nations, green parties were elected into parliament following the accident.[2] These electoral successes also translated to considerable political power in many European countries; already in the mid-1990s, green parties were represented in coalition governments in both France and Germany.

The paper makes a number of contributions. First, it adds to the wider social science literature on how exposure to environmental changes affects short-term policy preferences. Most of the previous studies focus on the electoral consequences for the incumbent party. A 2002 flood in Germany increased support for the incumbent party, as did a 2010 wildfire in Russia (Bechtel and Hainmueller, 2011; Lazarev et al., 2014). A plausible reason for the success of incumbents following natural disasters is that such events provides opportunities for governing parties to signal their quality to voters, causing voters to update their views about incumbents in a favorable direction (Ashworth et al., 2018). Contrary to this view, other papers studying the electoral consequences of natural disasters have found no effects on support for the incumbent (Bodet et al., 2016), or that the political effects depend on how vigorously the governing party responds to the event (Cole et al., 2012).

Second, it contributes to an extensive literature on other aspects of pollution. Exposure to air pollution contributes to lower birthweight and shorter stature among infants (Currie and Walker, 2011; Rosales-Rueda and Triyana, 2019), whereas early-life exposure to pollution has negative outcomes on future education outcomes and labor force participation (Currie et al., 2015b; Isen et al., 2017). In areas with close proximity to a toxic industrial plant, housing prices and productivity levels are lower, and mortality rates are higher (Currie et al., 2015a; Ebenstein et al., 2015; He et al., 2019). While numerous studies focus on the adverse effects of pollution, another strain of the literature points toward the economic benefits of pollution-generating activities. Oil and gas investments generate significant economic effects, including increased real wages, lower unemployment rates, and higher fertility rates (Feyrer et al., 2017; Allcott and Keniston, 2018; Kearney and Wilson, 2018). Understanding the political consequences of environmental accidents and natural disasters is important, considering that the frequency of such events is likely to increase as a result of global warming.

Finally, the natural experiment induced by regional variation in Chernobyl fallout levels has been used in several other studies, albeit answering different questions than the one posed in this paper. For instance, a study using the same setting and treatment, shows that children born in Swedish regions with high fallout exposure perform worse in secondary school, in particular in mathematics (Almond et al., 2009), even though the fallout level in affected municipalities were considered harmless by authorities. A further insight from the same paper is that babies born in high-fallout municipalities were less likely to graduate from high school, but that there were no effects on birth weight or neonatal mortality, suggesting that Chernobyl fallout chiefly impacted cognitive ability. Other studies have shown that more exposed individuals exhibit higher depression rates, lower subjective well-being, and lower labor market participation rates (Lehmann and Wadsworth, 2011; Danzer and Danzer, 2016). This article is the first to evaluate political outcomes of the disaster.

The reminder of the paper is structured as follows. Section 2 summarizes the Chernobyl disaster, and provides a brief background to the green movement in Sweden and elsewhere. Section 3 describes the data. Section 4 presents the empirical strategy, and presents the main results. Section 5 provides individual-level evidence about mechanisms, and Section 6 concludes.

2. Background

2.1. The Chernobyl disaster

On April 26, 1986, an explosion in reactor 4 of the Chernobyl nuclear power plant caused the release of large amounts of radioactive particles. The blaze burned for ten days, sending a plume of radiation across Europe. While the first radioactive cloud reached Sweden on April 27, the most significant rainfall was on the night between April 28 and 29. A nuclear accident leads to the release of many different radioactive particles, however, cesium-137, with a half-life of 30 years, is the most stable radioactive particle released during the disaster. Sweden received approximately 5% of total cesium fallout released during the disaster (Moberg, 1991).

To mitigate the risks to public health, restrictions limiting food consumption were enacted immediately after the meltdown in areas heavily affected by fallout. Restrictions were mostly in the form of threshold limits for consumption of meat, berries, fish and mushrooms, severely impacting day to day life in rural areas. The restrictions caused significant damage to animal life, as thousands of reindeer and other wild animals had to be destroyed due to contamination. As an additional side effect and regardless of formal restrictions, many people were too afraid to even go out in the open. There are numerous anecdotal accounts of this phenomenon. As one farmer from Delsbo in Gävleborg County, one of the most hard-hit areas in Sweden, describes it (Mörtberg, 2016):

> "Before Chernobyl, my wife used to pick blueberries, lingonberries and raspberries. But we quit that immediately. It probably took us ten years before we dared to do that again. And we did not start mushroom hunting until five years ago [in 2011]"

Notwithstanding the restrictions on food consumption, the impact on public health was significant. While the adverse health effects were considerably more pronounced in the Soviet Union, several studies suggest a positive relationship between fallout exposure in Sweden and cancer incidence (Tondel et al., 2006; Alinaghizadeh et al., 2016). The Swedish Radiation Safety Authority estimates that in the 50-year period following 1986, approximately 300 excess cancer deaths will occur in Sweden due to exposure to Chernobyl fallout (Hult, 2011). However, there was considerable geographical variation in exposure to fallout. In the most affected areas, ground deposition was close to that outside the Chernobyl exclusion zone, whereas other parts of Sweden were essentially spared (Almond et al., 2009). Importantly, regional variation in fallout exposure provides a natural experiment enabling us to assess the political consequences of the disaster.

[2] Following the disaster, green parties were elected into national parliaments in Austria (1986), Sweden (1988), Netherlands (1989) and East Germany (March 1990). In the December 1990 elections in reunified Germany, green parties received 8 out of 662 seats.

2.2. Environmental issues and politics in Sweden

In the late 1970s, Sweden had six reactors in operation. Although peaceful nuclear power was fairly uncontroversial during the 1960s and early 1970s, the 1979 Three Mile Island accident in Harrisburg, Pennsylvania, led to a surge in anti-nuclear activism in the Western world. At this time, Sweden was governed by a center-right government consisting of three parties with highly divergent views on nuclear power: the pro-nuclear Moderate Party, the Center Party, which was against, and the People's Party somewhere in between.[3] Amid the public debate following Harrisburg, the nuclear power issue caused internal government disagreement. To mitigate this, as well to accommodate public pressure to abandon nuclear power altogether, a nonbinding referendum on the future of nuclear power in Sweden was held in 1980.

Nonstandard for a referendum, there were three options available to voters: Options 1 and 2 favored the use of nuclear power until other energy sources could replace it, whereas Option 3 favored abolishment within ten years. The chief difference between Options 1 and 2 was that the latter specified that nuclear plants be owned by the government, whereas the former did not. Hence, Option 1 was supported by the center-right Moderate Party, and Option 2 was supported by the center-left Social Democrats, as well as the People's Party. Option 3 was supported by the Center Party, the communist Left Party, and a sizable faction within the Social Democrats. Option 2 won a plurality (39.1%), followed by Option 3 (38.7%) and Option 1 (18.9%), with 3.3% of the votes cast blank. Hence, there was no majority for an abolishment, and six reactors that were already under construction were commissioned between 1981 and 1985, increasing the total number of reactors to 12. As of 2023, there are still six reactors in operation in Sweden.

Despite large levels of radiation affecting significant parts of Sweden, the established parties showed no major signs of reconsidering their nuclear power policies. The anti-nuclear Center Party was aiming to form a coalition with the larger, pro-nuclear, Moderate-Party, meaning that they were forced to play down their anti-nuclear rhetoric. The Social Democrats, which received 45% of the votes in 1985 and managed to form a government, was nominally pro-abolishment both before and after the disaster. However, they had close ties to Sweden's largest blue-collar union, whose members dominated electricity-dependent sectors such as steelmaking and in the pulp and paper industry. Considering that nuclear power represented around 50% of Sweden's electricity production by the time of the disaster, there were fears within the Social Democratic party that any abrupt abolishment of reactors would lead to significant adverse effects on blue-collar jobs. Consequently, there was significant potential for an environmentalist anti-nuclear political party.

One year after the referendum, the MP was formed. From its founding, the party has been highly sceptical of nuclear power, advocating a transition to renewable energy sources. Its national vote share in the 1982 parliamentary elections was 1.7 percent, followed by 1.5 percent in 1985 and 5.5 percent in 1988. Sweden has a system of proportional representation, meaning that a party with x percent of the national vote share obtains approximately x percent of the seats. In order to claim any seats in parliament, a party must receive a higher vote share than the election threshold of 4%. Hence, it was not until the 1988 election – the first following Chernobyl – that the MP won seats in the national parliament, the *Riksdag*. Before their election to the Riksdag, the MP had limited financial resources, and did not conduct any targeted political campaigns in fallout-affected areas.[4] Besides Chernobyl, political scientists regard the sudden mass death of thousands of harbor seals (*Phoca vitulina*) along the Atlantic coast of Sweden in 1988 as contributing factor to the success of the MP. It was initially thought to be related to marine pollution, the regulation of which was a major issue for the MP.[5] The only major political event around this time was the February 1986 assassination of Social Democratic prime minister Olof Palme, which led to sympathy votes for the Social Democrats (Esaiasson and Granberg, 1996).

The breakthrough of the MP mirrored a similar development in other Western nations. In 1983, the West German Green Party won representation in the *Bundestag*, becoming the first major green party represented in a national parliament. In addition, the 1980s saw an increase in public awareness of other environmental issues, most notably regarding the depletion of the Earth's ozone layer (Christoff, 1994). The re-escalation of the Cold War in the early 1980s provided further boosts for green movements, as most green parties emphasized both environmental and peace issues (Rüdig, 2019). By 1998, green parties were junior coalition members in Finland, France, and Germany.

In recent years, the global upswing of green parties has accelerated due to mounting cross-country concern regarding the impact of climate change. In Sweden, however, the vote share of the MP has hovered around four to six percent since the early 1990s, as seen in Fig. 1. Over the years, the MP has de-emphasized nuclear power, and increased its focus on climate change and energy transition. Still, in the exit poll following the 2022 elections, a plurality of voters still regarded the MP as having the best policy on environmental issues.[6] Akin to its Green sister parties in other European countries, the MP is progressive in social issues, particularly with respect to immigration. Its liberal stance on immigration contrasts the views of the majority of the electorate, which is in favor of a more restrictive immigration policy (Bolin and Aylott, 2019). It had a supply-and-confidence agreement with the Social Democratic government during 2002–06, and were junior members in a center-left coalition with the Social Democrats between 2014 and 2021.

3. Data

3.1. Radiation data

To estimate Chernobyl fallout exposure in each municipality, I rely on aerial measurements of ground deposition of cesium conducted by authorities immediately after the accident, which commenced May 9, and lasted until June 3 (Bennerstedt et al., 1986). Fig. 2 illustrates the significant geographical variation in fallout levels observed following the accident. The northernmost parts of Sweden were essentially spared, as was most of southern Sweden. Instead, the highest concentration of ground cesium deposition was in coastal areas in the central parts of the country. The measure of ground contamination is in kilobequerels per square meter (kBq/m^2).

[3] The Center Party was the first major party in Sweden to demand that nuclear power be abolished (Asp and Holmberg, 1984, p. 34). However, the contrast vis-à-vis the MP was considerable: The Center Party was originally an agrarian party focusing on farmer interests, with energy policy being just one issue amongst others. Moreover, it had been in government on several occasions and was, thus, more of an "establishment" party, and consequently, less radical than the MP with respect to nuclear power.

[4] In Sweden, government subsidies are given to parties conditional on having received at least 2.5% in either of the two most recent parliamentary elections. Since the MP did not live up to this criterion before 1988, it did not receive public funding at the time of the disaster. Hence, there were little resources to conduct targeted campaigns. However, the co-chair of the MP at the time, Eva Goës, lived in Härnösand, one of the most fallout-affected municipalities. She was actively campaigning by speaking to voters and local media, even conducting radiation measurements using her personal Geiger counter. According to co-chair Birger Schlaug, this was not the result of some pre-agreed political strategy, but merely a consequence of Goës residing in the area. *Source*: Author's email correspondence with Schlaug.

[5] It was later concluded that the mass death of seals was caused by the virus *Phocine morbillivirus*, and was unrelated to pollution or eutrophication.

[6] The question was: "Which party has the best policy on environmental issues?". The MP received 26%. No other parties had above 15% for this question. Numbers are according to the poll by national public television broadcaster SVT.

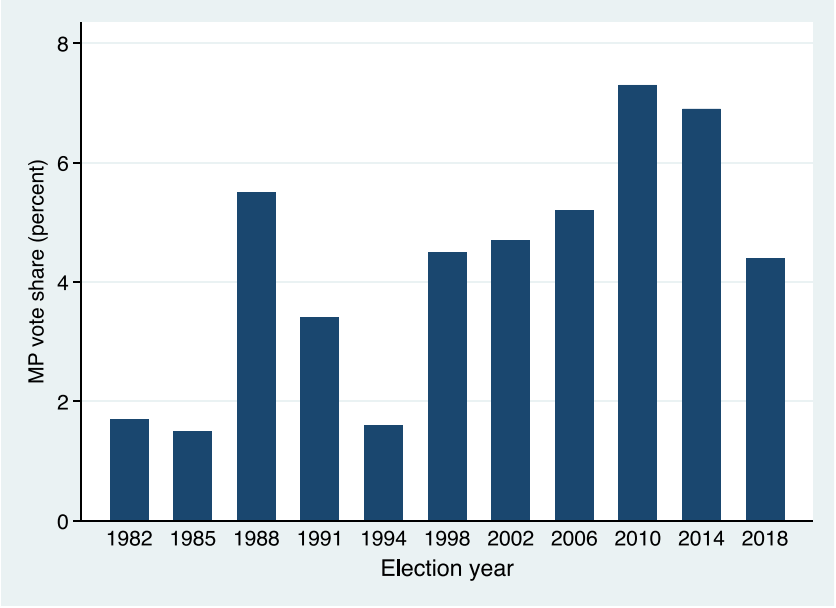

Fig. 1. Plot of the MP vote share for each election year between 1982 and 2018.
Data source: Swedish Statistics Agency.

In all, there were 284 municipalities (*kommuner*) in Sweden at the time of the Chernobyl disaster. These were divided into 24 counties (*län*). I then proceed by using ArcGIS to calculate the average ground deposition of cesium for each municipality. Considering that a unit increase in ground deposition represents a relatively modest change, an alternative approach is to construct a dummy variable taking the value one if ground deposition of cesium was greater than 37 kBq/m^2, and zero else.[7] This cut-off is often used by to define an area as contaminated, and many research papers examining the consequences of Chernobyl use this measure (cf. Almond et al., 2009; Balonov, 2017).

3.2. Election data and survey design

To test whether exposure to radioactive fallout affected electoral outcomes, our main explanatory variable of interest is the evolution of the MP vote share in parliamentary elections. Specifically, I use the municipality-level MP vote share, denoted MP_{it}, as the dependent variable. Online Appendix B provides further details into the data sources and definitions for all variables in the empirical analysis.

In addition to the election data, I use survey data from the annual *SOM*[8] survey in order to evaluate respondents' views on nuclear power, and whether exposure to Chernobyl fallout affected those views. The survey takes the form of a paper questionnaire, and I use survey data from 1986 to 2018.[9] As the name suggests, the questions survey respondents' views on politics, society, and media. A question on respondents' views on nuclear power has been asked every year, which allows us to investigate differences in attitudes towards nuclear power, both between municipalities, and between time periods.

The survey has two key features making it suitable for our analysis. First, the respondents are chosen randomly among the Swedish adult population (aged 16–85), which is important for inference. Secondly, the relatively large sample size – around 3500 observations per year – allows for municipality-level breakdown of attitudes towards nuclear power. However, many small municipalities will typically have relatively few observations for a given year. To overcome this obstacle, and to allow for consistency with the election results, I merge several survey waves to match the corresponding election years. For instance, one subsample corresponds to 1986–88, followed by 1989–91, 1992–1994, and so on.[10] This allows us to construct the variable $\textit{Support nuclear power}_{it}$ for municipality i and election period t as the share of respondents supporting the long-term use of nuclear power in Sweden. Matching survey data with fallout data allows us to examine whether there was a change in respondents' attitudes towards nuclear power between election years. Table A.1 of Online Appendix A presents the summary statistics for all variables used in the empirical analysis. Online Appendix B provides additional details on definitions and data sources for the variables used in the empirical analysis. Online Appendix C provides additional details on the structure of the questionnaire, as well as the exact wording of the questions and answers available to respondents.

4. The impact of fallout on the green vote

4.1. Year by year estimates

This section presents the voting results. First, to assess the impact of the Chernobyl disaster on the MP vote, I estimate the specification

$$\text{MP}_{it} = \beta_0 + \sum_{t \neq 1985} \beta_t \left(\text{Fallout}_i \times I_t\right) + \boldsymbol{\beta}' \boldsymbol{X}_{it} + \gamma_t + \eta_i + \varepsilon_{it} \tag{1}$$

where MP_{it} is the year by year z-score of the MP vote share for municipality i and time t, β_0 is a constant, Fallout_i is the ground deposition of cesium in the municipality, which is interacted with the corresponding election year dummies, denoted I_t for $t = 1982 \ldots 2018$. In addition, $\boldsymbol{X}_{it}$ is a vector of municipality-specific controls, γ_t is a year fixed effect, η_i is a municipality fixed effect, and ε_{it} is an idiosyncratic error term. The 1985 election is omitted for comparison. The reason behind the year by year standardization of the MP vote share is that the local MP vote share tends to vary with the average national support of the party. For the fallout measure, I consider both the standardized

[7] This threshold follows from an alternative measure of contamination (*curie*, Ci), where 1 Ci/km^2 = 37 kBq/m^2 (Maskalchuk, 2012).

[8] Shorthand for "Society, Opinion, Media" (*Samhälle, Opinion, Medier*).

[9] The 1986 survey, which was the first one, was sent to households in October 1986, six months after the Chernobyl accident.

[10] Starting in 1994, Sweden has used four-year terms.

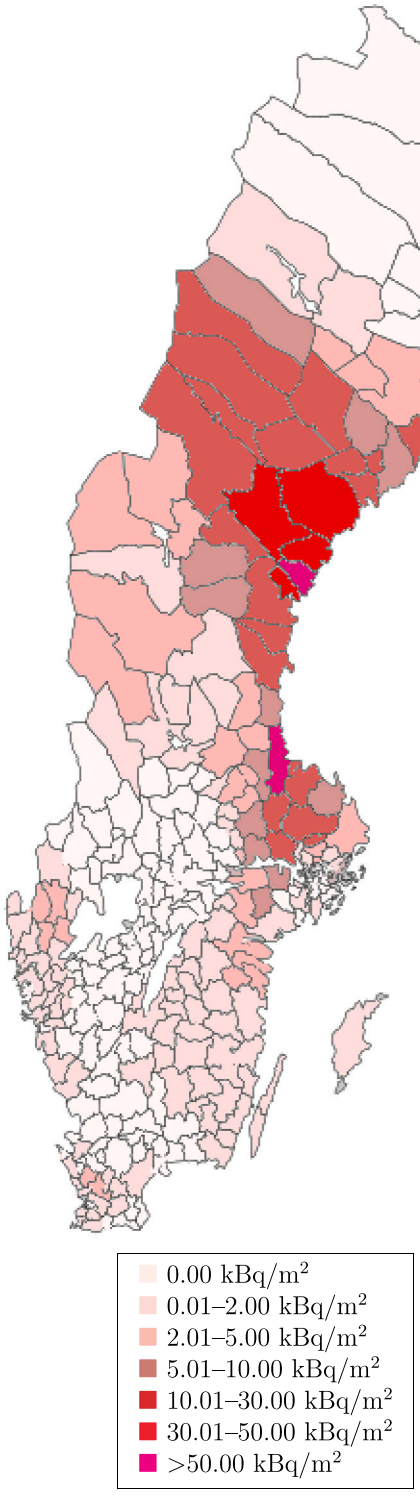

Fig. 2. Variation in average ground deposition at the municipality level.

average fallout level, as well as the binary variable equal to unity if the ground deposition of cesium was greater than 37 kBq/m^2, and zero else.

I begin by presenting the results without additional municipality-specific controls. The estimated β_t:s are plotted in Fig. 3, while Table A.2 of Online Appendix A gives the full results table.[11] To account for potential dependence based on spatial proximity, I use spatial corrected standard errors (Conley, 1999). As expected, there was no significant impact from fallout on the MP vote at the 1982 election, taking place several years before the accident. For the 1988 election, a one standard deviation higher ground deposition was associated with a 0.19 standard deviation higher MP vote share. It should be noted that the point estimate for the MP vote share was positive in 1982, and equal to around one-half of the estimated 1988 coefficient. Nevertheless, the coefficient for fallout is significant at the 1% level for the 1988 election. In the 1991 and 1994 elections, the magnitude of this coefficient decreased to approximately 0.13 standard deviations. After the 1994 election, none of the estimated β_t:s were statistically different from zero. Alternatively, we may consider the municipalities with ground deposition above 37 kBq/m^2. In these municipalities, the MP vote share in the 1988 election was around one standard deviation higher. In subsequent elections, the high ground deposition dummy was statistically insignificant.

To account for potential confounding factors not captured by the municipality fixed effects, Table A.2 of Online Appendix A includes the population in the municipality, its average annual income, the share of college graduates, the employment rate, 1980 referendum results for Option 3, as well as the indicator variable for municipalities heavily affected by the 1986 seal virus epidemic. Since the latter two controls are time-independent, they are interacted with the election dummies in order to serve as controls. There are only minor changes downwards in the coefficients after including these variables, suggesting that the controls are not driving our results. Finally, Fig. 3 illustrates that there was no increase in the MP vote share between the 2010 and the 2014 elections, suggesting that the 2011 Fukushima disaster did not affect MP voting.[12]

While we cannot fully exclude that the vanishing Chernobyl premium on the MP vote was partially due to the party shifting towards other issues, there are at least two arguments against. First, the findings on the long-term effects are consistent with previous research. A regional stimulus program enacted by the German government following severe flooding in 2002 increased voter support for the incumbent party in affected areas, however, more than half of the gains vanished in the following election, suggesting that voter memory is fairly short-lived (Bechtel and Hainmueller, 2011). Second, the rival Center Party abolished their anti-nuclear stance after the 2002 elections, making the MP the largest party that retained a significant focus on anti-nuclear issues (Forssblad, 2008).

4.2. Short-term effects on other parties and turnout

1. Effects on other parties in the 1988 election

The results presented previously suggest that it was primarily in the 1988 election, the first after Chernobyl, that fallout exposure led to significant changes in voter preferences in favor of the MP. To evaluate the effects on other parties in the 1988 election, I estimate

$$\Delta\text{Vote share}_i^{1985-88} = \beta_0 + \beta_1 \text{Fallout}_i + \boldsymbol{\beta}' \boldsymbol{X}_i + \varepsilon_i \quad (2)$$

Tables A.4–A.8 of Online Appendix A present the results when using the vote shares of the other parties in parliament: the incumbent Social Democrats, the anti-nuclear Center Party, the pro-nuclear Moderate and People's Parties, and the communist Left Party.

[11] As there were only 279 municipalities by the time of the 1980 referendum (as opposed to 284 in 1986), this is the number of observations in our model.

[12] To confirm this, Table A.3 of Online Appendix A presents the OLS estimates from regressing the percentage point change in the MP vote share between 2010 and 2014 on 1986 fallout levels. The coefficient estimate for 1986 fallout is statistically insignificant. This finding is expected considering that 25 years had passed between the two accidents.

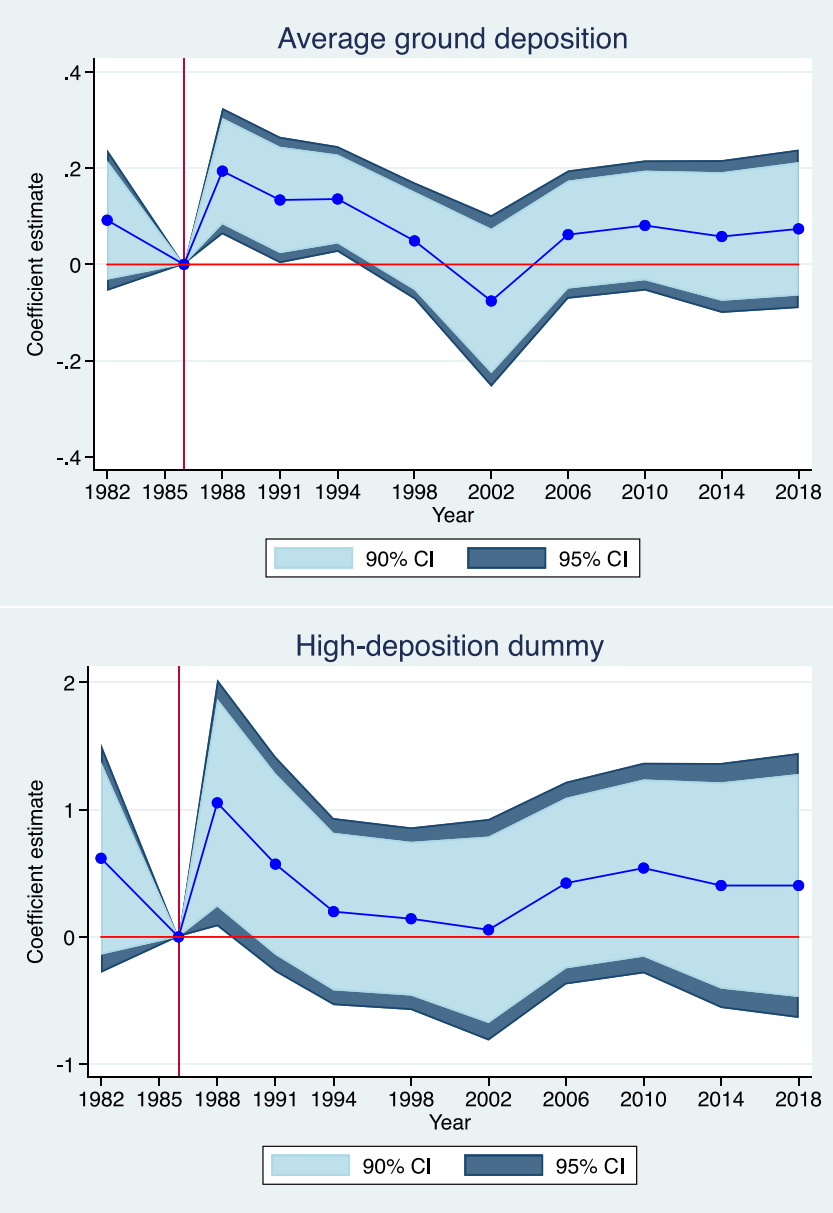

Fig. 3. Estimated Chernobyl effect on the MP vote share for each election 1982–2018, with the 1985 election omitted for comparison. The year of the accident, 1986, is marked with a vertical red line. The top panel uses the continuous measure, the bottom panel uses the high fallout dummy. 90% and 95% confidence intervals (CIs) are used. No controls included. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

The results show that fallout was significantly negatively related to Social Democratic vote shares. One standard deviation higher average ground deposition rates decreased the Social Democratic vote share by approximately 0.10 standard deviations. Thus, the decrease in the Social Democratic vote share is similar in magnitude to the increase in the MP vote share. Additionally, there was a positive effect on the vote shares of the Left Party, which was also against nuclear power, although this coefficient estimate is lower than the one for the MP. There were no statistically significant effects on the vote shares of the remaining parties, although it is notable that the establishment anti-nuclear Center Party decreased its vote share in fallout-effected muncipalities. For additional clarity, Table A.9 of Online Appendix A repeats these calculations using percentage point differences instead of the standardized differences for each party, including the MP.

2. Effects on turnout in the 1988 election

Did the accident lead to a mobilization of new voters? To examine the effect on turnout between 1985 and 1988, I estimate a similar model to the one above, namely

$$\Delta\text{Turnout}_i^{1985-88} = \beta_0 + \beta_1 \text{Fallout}_i + \boldsymbol{\beta}' \boldsymbol{X}_i + \varepsilon_i \quad (3)$$

where $\Delta\text{Turnout}^{1985-88}$ denotes the standardized percentage point difference in the turnout rate between the 1985 and 1988 elections for municipality i.

The results are presented in Table A.10 of Online Appendix A. The coefficient estimate $\hat{\beta}_1$ is statistically insignificant, suggesting that the increase of the MP vote share was solely due to shifting party

preferences among existing voters. As discussed above, this voter shift was chiefly due to voters abandoning the incumbent party, the Social Democrats.

4.3. Robustness

1. Parallel trends assumption

I proceed by testing the sensitivity of the main estimates in Fig. 3 from deviations from the parallel trend assumption, using the recently introduced Rambachan–Roth approach (Rambachan and Roth, 2023). This method relaxes the parallel trends assumption by allowing deviations from linearity up to a parameter M, where larger values of M lead to wider confidence sets. Fig. A.1 of Online Appendix A presents the estimated confidence intervals for the coefficient associated with Fallout $\times I^{1988}$, which is the main variable of interest in the paper. The estimated coefficient is statistically significant even when allowing for large deviations from the linear trend. Online Appendix D discusses the method in additional detail.

2. Placebo test

As a test of the identification strategy, Table A.11 of Online Appendix A gives placebo estimates, re-estimating (1) as a simple linear regression with the MP vote share difference between the 1982 and 1985 elections as the dependent variable. Since the 1982–85 term terminated one year before Chernobyl, the coefficient estimate for fallout should be zero. As expected, both when using the average ground deposition and the high-fallout dummy, the coefficient estimate for fallout is close to zero, and statistically insignificant.

5. Individual-level evidence

Did the positive effect on MP voting in 1988 mirror a change in attitudes towards nuclear power in fallout-affected areas? If the increased MP voting in response to fallout exposure was a result of concern about environmental accidents, we would expect public opinion to become more sceptical towards nuclear power after the accident. Another question arising is whether the lack of a long-term Chernobyl premium on the MP vote is similarly reflected in a change in attitudes toward nuclear power over time. To answer these questions, I use the results from the survey described in Section 3.2, allowing us to examine more closely the relationship between MP voting, fallout exposure and pro-environmentalist attitudes.

5.1. Relationship between fallout exposure and support for nuclear power

I start by considering the municipality-level relationship between fallout exposure and support for nuclear power. I use the same specification as the main analysis, replacing the outcome variable with z-scores of the share supporting nuclear power in each election period t for each municipality i. That is, the data is collapsed to match the election period level: 1986–1988, 1988–1991, 1991–1994, and so on. I let the 1980 referendum results serve as the reference category,[13] and estimate

$$\text{Support nuclear power}_{it} = \beta_0 + \sum_{t \neq 1980} \beta_t \left(\text{Fallout}_i \times I_t\right) + \boldsymbol{\beta}' \boldsymbol{X}_{it} + \gamma_t + \eta_i + \varepsilon_{it} \tag{4}$$

Interpretation is straightforward: Negative coefficient estimates $\hat{\beta}_t$ suggest that voters in affected areas were less inclined to support nuclear power, compared to the 1980 referendum. The results are presented in Fig. 4, and the full results table is presented in Table A.12 of Online Appendix A. One standard deviation higher fallout decreases support for nuclear power by around 0.1 standard deviations for the 1986–88 period, relative to pre-Chernobyl support. The magnitudes of the estimated coefficients are similar for the 1988–91 and 1991–94 periods, although the coefficient is statistically insignificant for the former. After 1994, there is no significant relationship between fallout exposure and support for nuclear power. When the high fallout dummy is used, only the results for the 1986–88 period is significant. In highly affected municipalities, support for nuclear power decreased by around 0.4 standard deviations compared to the 1980 referendum. A caveat to note is that for some smaller municipalities, the number of respondents may be low, even when several survey waves are collapsed into election periods. However, overall, the survey results are consistent with the voting results.

5.2. Media and voter information

1. Local media coverage depending on fallout levels

Another question is related to the process through which process voters gather information regarding local fallout levels. If voters were uninformed about the levels of fallout in their home municipality, it is unlikely that we would see variation in MP voting across municipalities. One potential channel through which voters update their knowledge about regional fallout levels is through local media. To answer whether there was a variation in newspaper coverage based on fallout levels, I use data from scanned print versions of the universe of Swedish newspapers from 2013 to 2019; in all, approximately 250 newspapers.[14] I then regress the number of times the words "cesium" and "Chernobyl" appear in the most-circulated newspaper for each municipality on the maximum and average fallout levels, after adjusting for the number of days per week the newspaper circulates.

The results are presented in Table A.13 of Online Appendix A, suggesting that the words "cesium" and "Chernobyl" are significantly more common in local papers of municipalities with higher fallout exposure. This is particularly evident for "cesium", and in municipalities outside the largest urban areas. Given this, it is likely that there was a regional difference in newspaper coverage of Chernobyl in the months and years immediately after the accident as well. Considering that cesium fallout is associated with significant health hazards, we would expect the MP to have higher potential among informed voters, that is, voters who frequently read the papers. This would, thus, provide a plausible channel for explaining the variation in the MP vote share across municipalities. I examine in the next section whether this was the case.

2. Media exposure and perceptions of nuclear power

Finally, the results of this paper have shown that support for nuclear power was lower in fallout-affected areas. The survey enables us to examine the mechanisms behind this stance in additional detail. Specifically, the survey asks respondents to evaluate a number of potential hazards related to nuclear power, and rate from 1 to 10 how worried he or she is about the hazard in question. Here, 1 is "not at all worried", and 10 is "very worried". I consider the survey years 1986–1988, that is, between the accident and the election. For each question, I calculate the share of very worried respondents (10 on the 1–10 scale), and regress this share on fallout levels and the municipality-specific controls. In addition, I consider both the entire sample, as well as limiting the sample to include only respondents who state that they read the local newspaper a minimum of six times per week. The hypothesis here is that newspaper readers are likely to be better informed about local fallout levels, impacting perceived risks and, eventually, party preferences.

[13] Formally, the inverse of the vote share for Option 3 (abolishment as soon as possible) is used as a proxy for the pre-Chernobyl share supporting nuclear power.

[14] Unfortunately, this data is not available for the years immediately after Chernobyl.

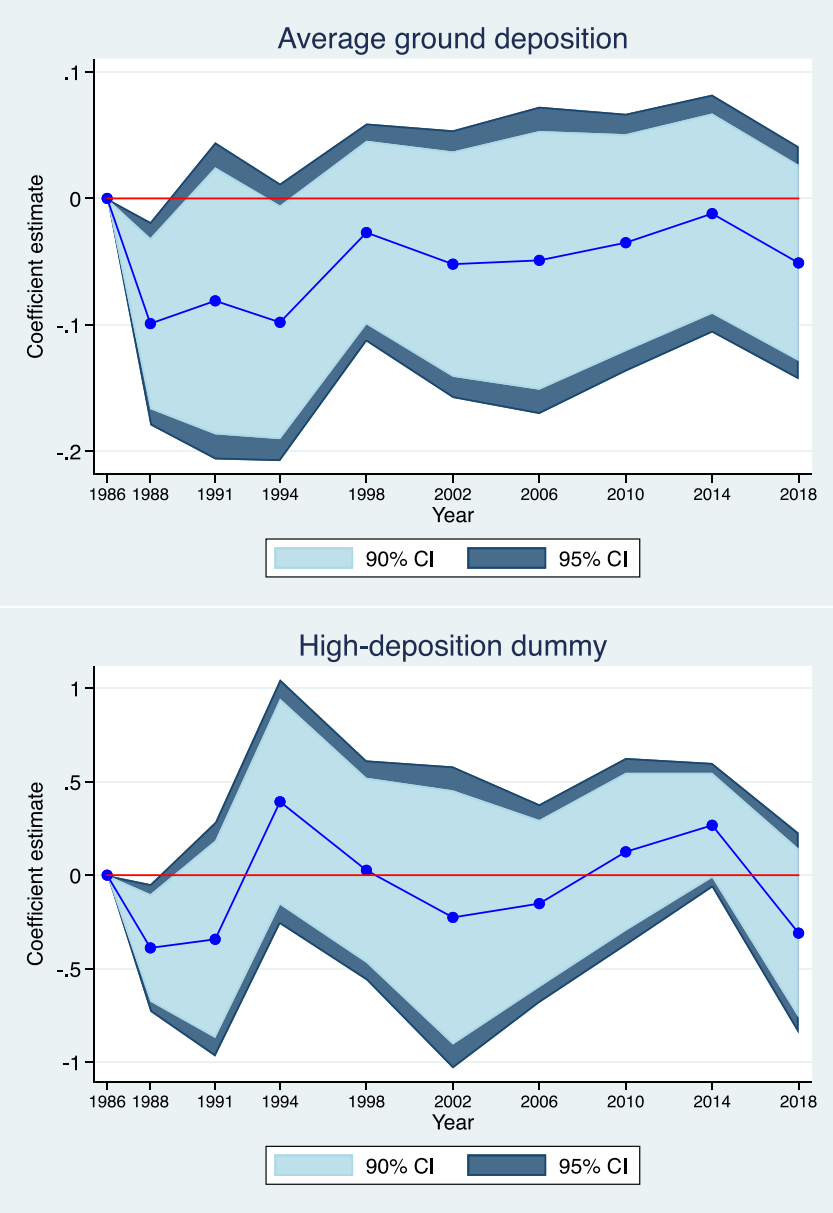

Fig. 4. Estimated Chernobyl effect on the share supporting nuclear power for each election 1988–2018. The baseline year is 1980, for which municipality-level variation in the pro-nuclear options in the referendum is utilized. The value for year of the accident, 1986, is marked equal to zero. The top panel uses the continuous measure, the bottom panel uses the high fallout dummy. 90% and 95% confidence intervals (CIs) are used. No controls included.

The results are presented in Table 1. Respondents are more worried about cancer incidence, deteriorated air and water quality, and the implications for future generations, than accidents or unsafe disposal of radioactive waste. Additionally, the estimated effect sizes tend to be larger when considering only the frequent paper readers. For instance, the share of respondents very worried about cancer incidence was around 0.4 standard deviations higher in high-fallout municipalities when the full sample is used, but around 0.5 standard deviations higher when only the frequent newspaper readers are considered. Consistent with the hypothesis outlined above, this finding suggest that negative opinions about nuclear energy, and consequently, increased MP voting, was driven primarily by well-informed voters.

6. Concluding remarks

Climate change is likely the largest threat to human well-being, and is a considerable policy challenge. Particularly, with global warming, natural disasters and environmental accidents will become more prevalent. This paper provides causal evidence that radioactive fallout from Chernobyl, one of the most disastrous environmental accidents in modern history, caused major changes in voter preferences. The environmentalist vote share increased in areas with significant ground contamination of cesium, with voters punishing the incumbent party. Individual-level survey data indicates that these changes are due to voters in affected areas becoming more sceptical towards nuclear power.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Table 1
Concern about nuclear risks and fallout exposure.

Outcome variable: Share very worried	Average ground deposition				High ground deposition dummy			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Panel A. Risk: "Major accident in Sweden"								
Fallout	0.002	0.015	−0.003	0.000	−0.099	0.033	−0.186	−0.006
	(0.041)	(0.041)	(0.006)	(0.006)	(0.267)	(0.261)	(0.274)	(0.270)
Panel B. Risk: "Higher incidence of cancer"								
Fallout	0.107**	0.112**	0.008	0.009	0.503**	0.621***	0.382*	0.505**
	(0.053)	(0.051)	(0.006)	(0.006)	(0.231)	(0.226)	(0.216)	(0.206)
Panel C. Risk: "Deteriorated air and water quality"								
Fallout	0.142**	0.139**	0.013*	0.014**	0.268	0.413	0.131	0.328
	(0.066)	(0.063)	(0.007)	(0.007)	(0.456)	(0.430)	(0.416)	(0.396)
Panel D. Risk: "Problems for future generations"								
Fallout	0.121**	0.104**	0.007	0.007	0.315	0.440*	0.200	0.366
	(0.049)	(0.045)	(0.005)	(0.005)	(0.258)	(0.264)	(0.237)	(0.244)
Panel E. Risk: "Unsafe disposal of nuclear waste"								
Fallout	−0.018	0.016	−0.008	−0.004	−0.065	0.107	−0.171	−0.007
	(0.043)	(0.043)	(0.006)	(0.006)	(0.203)	(0.149)	(0.217)	(0.185)
Only paper readers	No	Yes	No	Yes	No	Yes	No	Yes
Controls	No	No	Yes	Yes	No	No	Yes	Yes
Municipalities	284	279	284	279	284	279	284	279
Observations	4,614	3,675	4,614	3,675	4,614	3,675	4,614	3,675
Mean dep. var.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note. Outcome variable: Standardized share of respondents claiming to be "very worried" about each of the five risks associated with nuclear power use in Sweden. Column (1): No controls, full sample. Column (2): No controls, sample restricted to include only those who read a newspaper at least six times per week. Column (3): Controls for 1980 referendum results, and 1986 seal virus deaths, full sample. Column (4): Controls for 1980 referendum results, and 1986 seal virus deaths, restricted sample. A constant is included in all regressions. Spatial corrected standard errors in brackets. *, ** and *** denote significance at the 10%, 5% and 1% level, respectively.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jpubeco.2023.104964.

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