



Nuclear power plant closures and local housing values: Evidence from Fukushima and the German housing market[☆]



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ABSTRACT

The Fukushima Daiichi accident in Japan in March 2011 caused a fundamental change in Germany's energy policy which led to the immediate shut down of nearly half of its nuclear power plants. Using data from Germany's largest internet platform for real estate and employing a difference-in-differences approach, we find that Fukushima reduced housing prices near nuclear power plants that were in operation before Fukushima by 4.9%. Housing prices near sites that were shut down right after the accident even fell by 9.8%. Our results suggest that on the German housing market, the negative economic effects of the closure of nuclear power plants dominate potential positive changes in local amenities.

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1. Introduction

On 11 March 2011, Japan was struck by a devastating earthquake and tsunami, which led to a major accident at the Fukushima Daiichi nuclear power plant operated by Tokyo Electric

Power Company (TEPCO). This accident brought nuclear safety to the forefront of global attention. Nowhere, however, not even in Japan itself, did the Fukushima Daiichi accident have such repercussions on public opinion and energy policy as in distant Germany. Following mass anti-nuclear protests across Germany and a historic defeat in a state election in Baden-Württemberg, Germany's coalition government closed eight of the country's 17 nuclear power plants (henceforth, NPPs) in August 2011.¹ Scrapping a recent decision to extend the life of nuclear reactors by an average of 12 years, the German government also declared the phasing out of the remaining nine NPPs by 2022, a decision that made

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¹ The year 2011 saw the permanent retirement of 13 reactors in the world. Twelve of these retirements were due to the Fukushima Daiichi accident in Japan – four at the Fukushima Daiichi plant itself and eight in Germany. The thirteenth reactor was an old reactor in the United Kingdom (43-year-old Oldbury nuclear power station reactor 2). At the end of 2011, there were 435 reactors in operation worldwide, 2% less than at the beginning of the year ([International Atomic Energy Agency](http://www.iaea.org), 2012).

Germany the biggest economy to announce plans to give up nuclear energy.²

The impact of the Fukushima accident on Germany's energy policy is manifest. Not as easily seen, the Fukushima accident, and the U-turn in Germany's nuclear energy policy it caused, is likely to affect local economies in Germany. Plant closures and the nuclear phase-out might harm employment and reduce local business tax revenues in regions with NPPs. Such adverse local economic shocks have in fact been frequently discussed in the local and national press.³ The decision to phase out nuclear energy, in particular the closure of nuclear power plants, has also reduced the actual risk of a nuclear fall-out in German regions that host a NPP facility, while the accident itself may well have changed people's subjective perceptions of the risk of nuclear energy. Such changes in the (perceived) exposure to the risk of a nuclear accident should, in turn, affect local amenities. In a simple Rosen-Roback spatial equilibrium model (Rosen, 1979; Roback, 1982), both local labor demand shocks and changes in local amenities will be capitalized in housing values if the elasticity of local housing supply is sufficiently low (Glaeser and Gyourko, 2005; Moretti, 2011).

This paper uses data on individual houses listed for sale from Germany's largest internet platform for real estate to investigate the effect of Fukushima on the German housing market. Our empirical analysis compares the prices of houses located close to NPP sites with the prices of houses located further away from such sites before and after the Fukushima accident (*difference-in-differences* approach). We find that prices for real estate in the vicinity of NPPs that were in operation before Fukushima fell by almost 5% after Fukushima. This negative effect on housing prices could either reflect adverse economic effects of the nuclear phase-out or higher perceived risks of a nuclear accident. We expect economic effects to be more important near sites that were closed immediately (as they face immediate job losses), while perceived risks should be less important near such sites (as they are no longer in operation). We document that housing prices near sites that were closed after Fukushima fell by almost 10%, which suggests that economic rather than risk-related effects are of prime importance for falling housing prices. Consistent with this conjecture, we find that after Fukushima, employment fell sharply in municipalities whose NPP sites were closed.

Our main identifying assumption for a causal interpretation of our results is that conditional on control variables, which include a large set of individual house characteristics, housing prices in treatment and control regions would have followed the same trend in the absence of Fukushima. We corroborate this identifying assumption in various ways. For example, we show that pre-Fukushima trends in prices did not differ statistically between houses close to and further away from a NPP site. We also show

that our results do not change when we restrict the estimation sample to a more homogeneous set of regions (e.g., by excluding house offers from urban districts).

Our study relates to an extensive literature that has investigated the effects of undesirable facilities on local housing markets, such as fossil fuel plants (Davis, 2011; Blomquist, 1974), nuclear power plants (Nelson, 1981; Gamble and Downing, 1982; Folland and Hough, 2000), hazardous waste sites and waste incinerators (Gayer et al., 2000; Greenstone and Gallagher, 2008; Kiel and McClain, 1995), and major infrastructure projects, such as airports, railroads, or highways (Anselin and Lozano-Gracia, 2008; Caruthers and Clark, 2010; Cho et al., 2008; Cohen and Coughlin, 2008; Debrezion et al., 2007; Hughes and Sirmans, 1992). Our study contributes to this literature in several ways. First, our study is one of the first large-scale studies of NPPs, and, to the best of our knowledge, the first large-scale study of NPPs outside the US. Second, it is also one of the first studies to analyze the closure of a facility. Since the opening of a facility may trigger important adjustment processes, with households sorting across neighborhoods (Davis, 2011), the closure of a facility might not just reverse the effect of its opening.⁴ Third, our setting precludes anticipation effects that may otherwise complicate the identification of the effects of a site closure or opening. Potential home buyers or sellers could neither anticipate the Fukushima accident nor the subsequent change in Germany's energy policy. Moreover, the availability of house-level data from before and after the Fukushima Daiichi accident allows us to more forcefully control for differences between locations with and without a NPP site. Finally, our study assesses the relative importance of the potentially positive economic effect of large plants, with their potential to boost local employment and lead to positive economic spillovers (Greenstone et al., 2010), and their local disamenities.

Our setting has the unique feature that it permits us to study the response of housing prices to a distant event that did not in any physical way affect individual houses. The radiation released by the Fukushima Daiichi accident in Japan did not have a measurable impact on the environment in Germany, and neither did the tsunami that caused this accident. In recent work, Fink and Stratmann (2015) study the effect of the nuclear accident in Fukushima on housing prices in the United States. Using monthly zip-code level data on median home prices before and after Fukushima, the authors find that prices in regions close to nuclear reactors did not fall relative to prices in regions further away. This finding is at odds with the hypothesis that housing prices in the vicinity of NPP sites may have suffered because residents updated their nuclear risk perceptions after the Fukushima Daiichi accident. Other than in Germany, no NPP in the United States was closed and none suffered a reduction in its remaining operation time.

The paper proceeds as follows. Section 2 provides background information on Germany's NPP sites, and reviews the chronology of government responses and changes in Germany's energy policy following the nuclear accident in Japan. It also discusses potential mechanisms through which the Fukushima Daiichi accident and the resulting change in Germany's nuclear energy policy may have affected housing prices near German NPPs. Section 3 describes the real estate data and the identification strategy we

² After the Fukushima Daiichi accident, Japan decided to phase out its NPPs by the end of the 2030s. The new government under prime minister Shinzo Abe, however, announced to re-start those NPPs that pass new and stricter security standards. Other countries, such as Belgium, Italy and Switzerland have re-evaluated their nuclear programs (International Atomic Energy Agency, 2012). Switzerland decided in May 2011 to not extend operation times of existing NPPs anymore and to ban the construction of new reactors. The first Swiss NPP will presumably close in 2019, the last in 2034. In Italy, a referendum held in June 2011 stopped plans of the Berlusconi-led government to build a new NPP, thereby keeping Italy non-nuclear. Italy's four NPPs had been closed following a referendum in 1987. In Belgium, plans to extend remaining operation times of the country's two oldest NPPs were scrapped in July 2012, and the two NPPs are now scheduled to close in 2015. The last Belgian NPP will close in 2025.

³ For instance, the German weekly magazine *Der Spiegel* wrote in its online edition on 2 June 2011: "The nuclear phase-out puts strain on local municipalities: Eight NPPs are closed lightning fast. As a consequence, the municipalities will lose millions in business taxes". And the *Südhessen Morgen*, a local newspaper, wrote about the situation in the Hessian town of Biblis: "The closing down of the nuclear power plant is a major blow for Biblis. [...] It will lead to significant losses of purchasing power and to distortions on the housing market".

⁴ Kiel and McClain (1995) show that the effect on property prices of an incinerator is not constant over time but varies over the siting process and the operation time of the facility. However, the authors do not consider the closure of the incinerator. Currie et al. (2015), in their analysis of the effect of toxic industrial plants on the housing market, distinguish explicitly between plant openings and plant closures. They find that plant openings decrease housing prices within 0.5 miles of the plant by around 11%, whereas plant closures have no effect on housing prices. Davis and Hausman (2016) study the closure of a large nuclear plant in California but focus on the effect of the closure on carbon dioxide emissions and the private cost of electricity generation.

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