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JEL classification: R31, Q48, Q58.

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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 the 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 of its own to extend the life of nuclear reactors by an average of 12 years, the government also declared the phasing out of Germany's remaining nine NPPs by 2022, a decision that made 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. However, the Fukushima Daiichi accident, and the U-turn in Germany's nuclear energy policy it caused, is likely to have an effect also on local economies in Germany. Plant closures and the nuclear phase-out may harm employment in regions with an NPP or reduce local business tax revenues. Such adverse economic effects, which will only unfold over time, are in fact frequently discussed in the local and national press.[3] The Fukushima accident may also have changed people's perceptions of the risk of nuclear energy, and the decision to phase out nuclear energy has reduced the actual risk of a nuclear fall-out in Germany. Both (expected) local economic effects and updated risk perceptions should be reflected in local house prices. For residential property is not only a consumption good but also an asset whose present value depends both on current and future conditions in a locality.

This paper uses data on individual house offers 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 Fukushima (*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 6% after Fukushima. House prices near sites that were shut down permanently right after the accident even fell by 10.8%. In contrast,

[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, 2012).

[2] After the Fukushima Daiichi accident, Japan decided to phase out its NPPs until 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 programmes (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 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 *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 on 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."

Fukushima had no effect on house prices near NPP sites that were inactive at the time of the accident.

Our main identifying assumption for a causal interpretation of our results is that conditional on controls, among them a large set of individual house characteristics, house 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 an 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 the first study to analyze the closure of a facility. Since the opening of a facility may trigger important adjustment processes, with households sorting across neighbourhoods (Davis, 2011), the closure of a facility will in all likelihood 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 house 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.

Our setting has the unique feature that it permits us to study the response of real estate prices to a distant event that did not in any physical way affect the estate. 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 (2013) study the effect of the nuclear accident in Fukushima on house prices in the United States. Using zip-code level data on the median value of single-family houses before and after Fukushima, the authors find that house values in regions within a 25-mile radius of a NPP site appreciated slightly after Fukushima. This finding is at odds with the hypothesis that house 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 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

[4]Kiel and McClain (1995) show how the effect on property prices of an incinerator varies over the siting process and the operation time of the facility.

German NPPs. Section 3 describes the real estate data and the identification strategy we use in our empirical analysis. This section also provides summary statistics, disaggregated by distance to NPP sites, on basic amenities of property that is offered for sale prior to and after the Fukushima Daiichi accident. Section 4 presents and discusses our regression results. Section 5 concludes.

2 Background

2.1 Fukushima and German Energy Policy: A Chronology of Events

When the Tohoku earthquake and Tsunami struck Japan on 11 March 2011, there were 15 NPPs in operation at ten sites in Germany (see Figure 1 for their location in Germany).[5] Another two NPPs, Brunsbüttel and Krümmel, had been inoperative for several years[6] without a final decision to close them permanently.

Only three days after the Tsunami in Japan, the German federal government announced a 3-month nuclear moratorium that took immediate effect. During the moratorium, the seven oldest NPPs (including the already inoperative NPP Brunsbüttel) were temporarily shut down within three days of the government's announcement (see Table A-1 in the Appendix). On 22 March 2011, the government set up two commissions, one to assess security standards at German NPPs (the so-called *Reaktorsicherheitskommission*), and one to inquire into the risk of atomic energy that the German population was still willing to bear after the Fukushima Daiichi accident (the so-called *Ethikkommission*).

Despite these initiatives, the ruling Christian Democratic Party of Chancellor Merkel suffered a historic defeat in the state election in Baden-Württemberg on 27 March 2011. After ruling the state since its foundation in 1952, the Christian Democrats were ousted from office by a coalition of Social Democrats and Greens. The Greens, which traditionally oppose nuclear energy, scored their all-time best state election result, and their top candidate became the first green leader of a German state (*Ministerpräsident*). Commentators agreed that the Fukushima accident had significantly influenced the election result.[7] In the eyes of many voters, the accident had proved wrong the pro-nuclear energy policy of the federal coalition government of the Christian Democratic Party and the Liberal Democratic Party, which only half a year earlier had extended remaining operation times of the existing NPPs in Germany.[8]

On 30 May 2011, shortly after the two commissions had issued their final reports, the German federal government announced that it would permanently shut down all seven NPPs that had been temporarily shut down under the moratorium. The government also decided to permanently close the notoriously accident-stricken NPP Krümmel, which had already been inoperative since the summer of 2007. In addition, the government also reversed its previous decision to extend the operation times of the nine remaining NPPs.

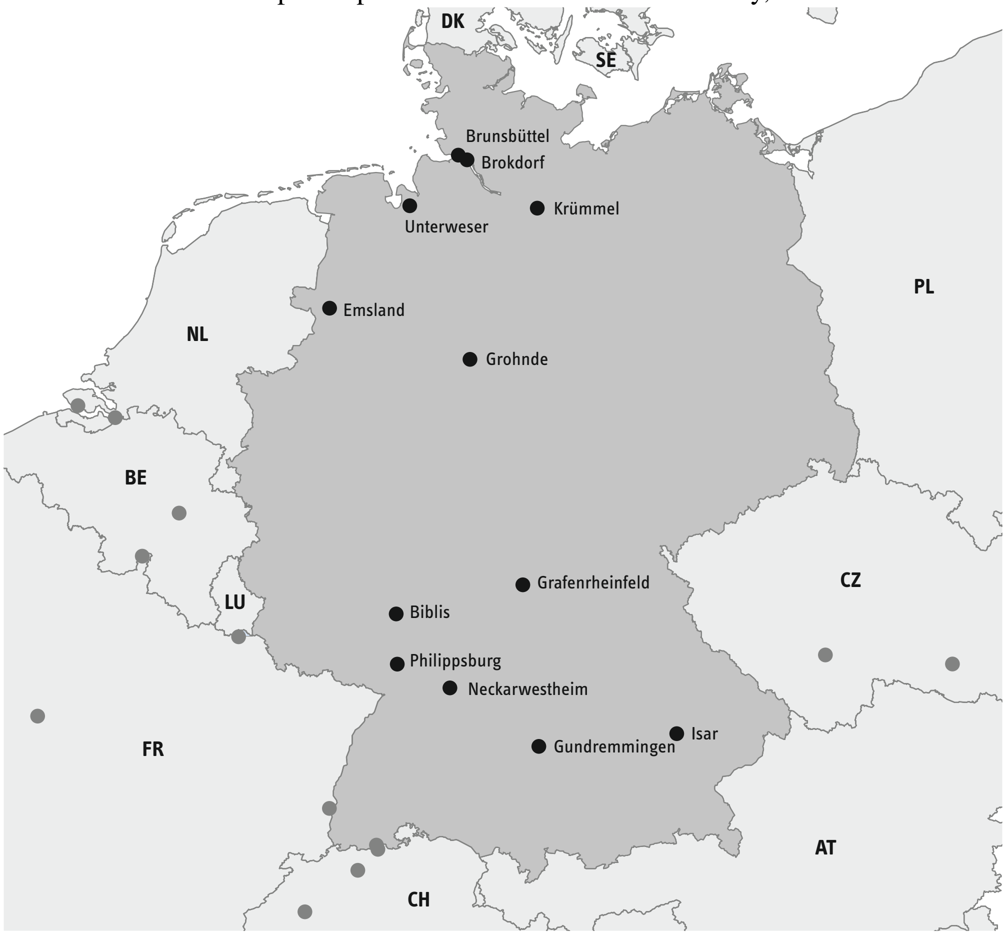
[5] One of these NPPs, Biblis-B, had been disconnected from the grid two weeks before Fukushima for regular inspection scheduled for 25 February 2011 to 22 May 2011 (Deutsches Atomforum, 2012).

[6] NPPs Brunsbüttel and Krümmel had shut down in the summer of 2007. Brunsbüttel has remained inoperative ever since, while Krümmel has resumed operation only for a short time in June 2009 (Department of Nuclear Safety, 2011, 2012).

[7] See, for instance, the online comments in *Die Zeit* ("Die Wahl der Spätentscheider") or *Rheinische Post* ("Fukushima 21: Das waren keine normalen Wahlen") on 28 March 2011.

[8] The Christian Democrats and the Liberals had already announced plans to extend the operation times of existing NPPs during their campaign for the national election of September 2009. After a lengthy discussion about the exact terms of the extensions, the coalition parties agreed on 5 September 2010 that the operation times of NPPs should be increased by an average of 12 years per reactor. The corresponding law was approved by the German parliament on 28 October 2011.

FIG. 1: Nuclear power plant sites in and close to Germany, March 2011



Note: German nuclear power plant (NPP) sites are marked by black dots and with name. Foreign NPPs are marked by grey dots and without name.

The German parliament approved these measures by great majority on 30 June 2011.[9] Taking effect on 6 August 2011, the seven moratorium NPPs and NPP Krümmel lost their operating license (see Table A-1). None of these eight NPPs had been re-connected to the grid after the moratorium expired in mid-June. The last NPP in Germany will now close in 2022. Most Germans either welcomed the government decision (44%) or considered the closure date for the last NPP as ”too late” (31%) (Infratest dimap, 2011b).

2.2 Fukushima and the German Housing Market: Theoretical Considerations

The nuclear disaster at Fukushima, and the change in Germany’s energy policy it caused, might have large effects on local housing markets near German NPPs. In general, real estate is both a consumption good and an asset. House prices therefore depend on local economic conditions and amenities – and on their future development. Fukushima and the nuclear phase-out in Germany might affect German house prices through two channels: first, by affecting local economies, and second, by changing the actual and perceived risk of

[9] 13th Amendment to the Atomic Energy Act (*13. Gesetz zur Änderung des Atomgesetzes*).

nuclear energy. We discuss both channels in turn.

Consider the economic channel first. The nuclear phase-out in Germany is likely to have adverse effects on local economies near NPP sites.[10] NPPs are usually important local employers. The German electric utilities company *RWE*, for instance, used to employ around 700 workers at the NPP site in the small Hessian town of Biblis. Subcontractors employed another 300 workers at the site. All in all, the NPP Biblis provided work for almost 1000 workers – in a town of just 9000 inhabitants. Ten months after NPP Biblis was closed, RWE announced that it will reduce employment at the site from 645 to 470 workers until the end of 2012 (RWE AG, 2012). Another 50 of its workers, along with the great majority of workers from subcontracting firms, had already left the site by that time. Many of the remaining 500 workers will for now continue working at the site. Regular inspections in the post-operation period and the dismantling of the NPP in the future still require specialized staff. The employment effects of the nuclear phase-out will therefore not materialize at once, not even at sites which were closed immediately. Moreover, the closure of a NPP might not only reduce labor demand at the site itself but also in the region more broadly. In regular intervals, usually once a year, large-scale renewal and maintenance work takes place at NPP sites. The maintenance work, which often lasts for several weeks, requires many external engineers and assembly operators to work at the site in addition to the regular work force. These external workers often stay in local hotels and eat in local restaurants. The closure of a NPP is therefore likely to hurt also the local hotel and restaurant industry. Finally, the nuclear phase-out will also reduce business tax revenues, the most important source of revenue for local municipalities.[11] Deteriorating local economic conditions are likely to be reflected in falling house prices. In the short run, effects might be strongest in regions in which a NPP site was closed immediately. But even in regions where only the operation time of the local NPP was reduced, house prices might fall if people anticipate adverse economic effects in the future.

The second channel through which Fukushima might affect local housing markets is through its effect on the perceived and actual risk of nuclear energy. After Fukushima, people might perceive nuclear energy to be more risky than before the accident – and therefore might be less willing to live close to a NPP. Right after the accident, the majority of Germans (70%) thought that a severe nuclear accident, comparable to that in Japan, could happen in Germany as well (Infratest dimap, 2011a). The share of respondents in favour of a nuclear phase-out increased from 62% in August 2010 to 71% on 14 March 2011. Even the German chancellor Angela Merkel, a trained physicist, explained the change in Germany's energy policy by changes in the risk assessment of nuclear energy. "Before Fukushima, I accepted the residual risk of nuclear energy because I was convinced that this risk will not materialize in a high-tech country with high security standards", she stated in a parliamentary speech on 9 June 2011. "Fukushima made us aware of the fact that even in a high-tech country such as Japan, the risk of nuclear energy cannot be controlled with certainty."[12] If Fukushima has indeed increased the perceived risk of nuclear energy, people might be less willing to

[10]There are numerous newspaper articles on the adverse effects of site closures on local economies. See, for instance, the online articles in *Frankfurter Rundschau* on 2 October 2012 ("Eine Stadt sucht ihre Zukunft") or in *Kreiszeitung Wesermarsch* on 10 March 2012 ("Beschäftigte hoffen auf Rückbau").

[11]In, Biblis, for instance, the NPP accounted for more than 50% of local business tax revenues (see *Spiegel Online*, "Ende der AKW-Ära: Atomausstieg kostet Kommunen Millionen", 1 June 2011).

[12]Translation by the authors. The speech can be accessed in German on http://www.bundesregierung.de/Content/DE/Regierungserklaerung/2011/2011-06-09-merkel-energie-zukunft.html.

live close to a NPP. This should ceteris paribus cause house prices to fall. However, the political decision to phase out nuclear energy has reduced the actual life span of NPPs – and has even led to the immediate closure of specific NPP sites. The phase-out has therefore reduced the actual risk of a nuclear accident. This should ceteris paribus increase the relative attractiveness of houses in the vicinity of NPPs.[13] Whether the positive effect on house prices (through a reduced actual risk) or the negative effect (through an increased perceived risk) prevails is unclear. However, the overall risk effect is likely to be positive near NPPs that were closed immediately after Fukushima. After all, local residents no longer life near an operating NPP, and increases in their risk perceptions of operating NPPs are therefore no longer relevant for their housing decisions.[14]

Summarizing the above, the Fukushima accident is likely to decrease local house prices near German NPPs if the accident increased the perceived risk of nuclear energy. The nuclear phase-out, which followed the accident, is also likely to decrease house prices, as it adversely affects local economies. At the same time, however, the phase-out also tends to increase local house prices by reducing the actual risk of a nuclear disaster through site closures and cuts in maximum remaining operating times. A priori, therefore, the overall effect on house prices near German NPPs is ambiguous.

3 Empirical Strategy and Data

3.1 Empirical Strategy

To identify the effect of the Fukushima Daiichi accident on the prices of houses located next to a NPP site, we apply a difference-in-differences (DiD) approach by running variants of hedonic price functions of the following type:

$$Y_{ijt} = \alpha + X_i\beta + \gamma NPP_i + \zeta Fukushima_t + \delta(NPP_i \times Fukushima_t) + D_j + D_t + \varepsilon_{ijt} \quad (1)$$

where Y_{ijt} is the log asking price of property i in region j in month t, X_i is a vector of house characteristics, NPP_i is a dummy for property located in the vicinity of a NPP site, and $Fukushima_t$ is a dummy for the time period after the Fukushima Daiichi accident. D_j is a full set of region dummies, D_t a full set of month dummies, and ε_{ijt} is an error term.

The treatment effect of interest is δ. It captures differences in the pre- to post-Fukushima change in the average price of houses located next to and further away from a NPP site. The vector X_i controls for observable property characteristics, and therefore also for changes in the composition of offered houses over time. Property characteristics include age (and its square), a dummy for property still under construction, living space (and its square), base area (and its square), and a dummy for detached houses. In our baseline specification, the NPP_i dummy is equal to one if a house is located within 5km of a NPP site. The dummy captures time-invariant mean level differences in the price of houses located in the vicinity of NPP sites. D_j captures

[13] As house prices reflect both the present and the future risk of a nuclear disaster, house prices may not only appreciate near NPPs which were closed but also near NPPs that only saw a reduction of their operation time.

[14] Admittedly, NPPs carry some risk for their environment even after they are closed. For instance, fuel rods still have to be cooled in the immediate post-operation period, as they would melt otherwise.

time-invariant differences in housing prices between small regional units. In our baseline specification, we define these regional units on the zip-code level, of which there are 9,276 in our estimation sample. If not noted otherwise, standard errors are clustered at this regional level. Finally, the full set of month dummies D_t captures aggregate changes in house prices.

Potential buyers and sellers in the German housing market could not anticipate the Fukushima accident and the subsequent change in Germany's energy policy. Therefore, we can rule out anticipation effects: the treatment (Fukushima) had not effect on housing prices in the pre-treatment period. The main identifying assumption of our difference-in-differences approach is that conditional on controls, prices of houses located close to an further away from a NPP site would have followed the same trend in the absence of Fukushima. We corroborate this identifying assumption by a series of robustness and specification checks. In particular, we test for differences in pre-Fukushima trends between houses in treatment and control regions, and exclude urban areas to increase the homogeneity of the analyzed regions. In additional regressions, we also add additional property-to-NPP distance measures to see how quickly any potential Fukushima effect levels off with distance, use municipality and county instead of zip-code fixed effects, and confine the estimation sample to new offers only. We also run more elaborate specifications, in which we allow the treatment effect to differ between operating NPP sites that were shut down post Fukushima and NPP sites that were not. This allows us to assess whether full site closure had a different impact on house prices than partial site closure[15] or mere reductions in the maximum remaining operation times of NPPs.

3.2 Data and Descriptive Statistics

For our analysis, we use monthly house price data provided by the internet platform *ImmobilienScout24*, Germany's leading online property broker.[16] Data on individual house prices and house characteristics stem from property offers that individuals place on this platform.[17] The data set is very large, and therefore suitable for the analysis of regional house prices (Bauer et al., 2013). The data set provides information on property characteristics and the exact geocode of each property. *ImmobilienScout24*, however, does only record asking but no transaction prices. This can be a potential drawback, especially if the difference between asking and transaction prices varies systematically with property amenities or characteristics of localities. In a recent analysis for rural areas in the German state of Rheinland-Pfalz, Dinkel and Kurzrock (2012) show that asking prices on *ImmobilienScout24* do exceed actual transaction prices on average by 15%. However, the study also shows that the asking price premium does not vary systematically with house or neighborhood characteristics.

Our estimation sample consists of single-unit houses that were offered for sale between March 2009 and May 2012. We exclude house offers for which information on property characteristics is missing. We also

[15]These are two block sites that suffered closure of one block only.

[16]See http://www.immobilienscout24.de/. Bauer et al. (2013) provide a detailed description of the data.

[17]The posting of an offer on ImmobilienScout24 is costly. Fees depend on posting duration (two weeks, one month, three months), the type of real estate offered (e.g. houses or flats), and the type of offer (for sale, for rent). Postings can be modified anytime during purchased posting time. Posting durations are automatically extended (and additional fees payable) if purchased posting time expires and individuals have not deactivated their posting beforehand. Individuals are reminded by ImmobilienScout24 of pending expiration deadlines.

exclude observations with very unusual property characteristics.[18] Moreover, we drop March 2011 offers from our estimation sample, as this month saw the accident at Fukushima (on 11 March). Finally, we also exclude the 401 observations of houses that are located within 5km from the French NPP of Fessenheim or the Swiss NPP of Leibstadt.[19] After these restrictions, the total sample consists of an unbalanced panel of 3,254,139 offers for 897,209 houses.

Table 1 provides summary statistics for sale offers prior to and after the Fukushima accident for houses located at least 5 km and less than 5 km from a NPP site (see columns (1) and (5), and (4) and (8)). Average offer prices fell slightly pre- to post-Fukushima for houses within 5 km of a NPP site (−1,335 Euro) but increased somewhat for houses located more than 5 km away from a NPP site (+1,876 Euro). The difference of these two differences, i.e. the unconditional difference-in-difference (DiD) estimate, is −3,211 (see column (9) of Table 1). This suggests that Fukushima had a small negative effect on house prices near NPP sites. The unconditional DiD estimate is, however, not statistically different from zero (standard errors are clustered at the zip code level). The same holds for the unconditional DiD in log prices (+1.0%), the independent variable of our regression analysis. However, the descriptives also suggests that the change in house prices near operating NPPs differed greatly from the change in house prices near non-operating NPPs. Prices near the NPP sites of Brunsbüttel and Krümmel that were already inactive before the Fukushima disaster increased by almost 20,000 Euro after Fukushima (see columns (3) and (7)). In contrast, prices near operating NPPs fell by more than 10,000 Euro (columns (2) and (6)). It is therefore important for our analysis to distinguish between the effect of Fukushima on house prices near operating and non-operating NPPs.

Finally, Table 1 also shows that there exist some pronounced differences in property characteristics between houses in treatment and control regions. Houses near NPP sites, and especially those near Brunsbüttel and Krümmel, tend to be considerably cheaper. They are also older and of smaller base area. Moreover, houses near NPP sites are also less often under construction and a detached property. These differences in levels exist both before and after Fukushima. Unconditional DiD estimates reported in column (9) of Table 1 suggest that Fukushima had no statistically significant effect on average property characteristics of houses offered near NPP sites.

[18] We exclude houses with a reported base area of less than 50 or more than 10,000 square meters, houses with a reported living space of less than 25 or more than 500 square meters, and houses with an asking price of less than 1,000 or more than 10 Mio. Euro. Furthermore, we exclude houses with more than 11 rooms and houses that are older than 200 years.

[19] Adding these observations to the treatment group does not change our results.

TABLE 1: SUMMARY STATISTICS BY DISTANCE TO NPP SITE, BEFORE AND AFTER FUKUSHIMA

	Before Fukushima				After Fukushima				DiD
	Distance to next NPP < 5 km			≥ 5 km	Distance to next NPP < 5 km			≥ 5 km	
	all	operating	non-operating		all	operating	non-operating		[(5) − (1)]− [(8) − (4)]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Price (Euro)	219,136	236,667	173,219	263,876	217,801	226,177	192,441	265,752	-3,211
	[112,665]	[120,350]	[71,371]	[199,209]	[104,179]	[107,725]	[87,926]	[216,854]	(7,429)
Log Price (Euro)	12.183	12.263	11.972	12.299	12.172	12.215	12.041	12.278	0.010
	[0.488]	[0.481]	[0.442]	[0.597]	[0.519]	[0.502]	[0.548]	[0.645]	(0.031)
Age (years)	35.670	33.028	42.591	31.356	40.430	40.313	40.782	36.395	-0.230
	[32.446]	[33.064]	[29.683]	[30.901]	[31.903]	[32.934]	[28.567]	[32.261]	(1.998)
In construction (%)	4.582	6.180	3.972	4.804	1.876	2.431	1.963	2.967	-0.869
	[20.911]	[24.082]	[6.292]	[21.386]	[13.570]	[15.404]	[4.428]	[16.968]	(1.930)
Living space (m^2)	148.162	152.125	137.781	154.209	151.531	155.144	140.592	156.034	1.544
	[53.644]	[55.153]	[47.957]	[56.897]	[49.014]	[47.106]	[52.926]	[59.077]	(2.896)
Base area (m^2)	710.547	666.383	826.220	753.508	733.312	676.084	906.571	803.130	-26.857
	[710.220]	[638.117]	[860.741]	[807.718]	[729.294]	[571.042]	[1056.328]	[863.935]	(30.088)
Detached house (%)	27.205	27.735	25.819	32.205	27.461	27.877	26.202	30.054	2.406
	[44.505]	[44.773]	[43.775]	[46.726]	[44.637]	[44.847]	[43.995]	[45.849]	(2.484)
Observations	7,289	5,275	2,014	2,144,085	4,104	3,085	1,019	1,098,735	3,254,213

NOTE: Columns (1) to (8) show the mean of each variable for property located within or outside a 5 km range of a NPP site. Among the property within the 5 km range, we further distinguish between property near sites that were operating before Fukushima and those that were not (NPPs Brunsbüttel, Krümmel). Averages are calculated for the pre-Fukushima period March 2009 to February 2011 and for the post-Fukushima period April 2011 to May 2012. Standard deviations are reported in square brackets (columns (1) to (8)). Standard errors clustered at the zip code level are reported in round brackets (column (9)).

4 Results

4.1 Main Results

The starting point for our regression analysis is the unconditional DiD estimate of the effect of Fukushima on log house prices near NPP sites. We reproduce the unconditional DiD estimate of $+1.0\%$ in column (1) of Table 1. In a regression framework, we obtain this estimate by estimating equation (1) without property characteristics, region and months fixed effects. After adding month dummies and zip code fixed effects to our regression, we estimate a treatment effect of -4.1% (column (2)). The effect is, however, still not statistically significant. We next add property characteristics to account for potential changes in the composition of offers over time (column (3)). The coefficient estimate of the treatment effect does not change but is now measured more precisely (and statistically significant at the 5% level). The estimate suggests that Fukushima decreased house prices near German NPPs by 4.1% (relative to houses further away from NPPs).

TABLE 2: MAIN REGRESSION RESULTS

	(1)	(2)	(3)	(4)	(5)
Treatment effect:					
NPP $<$ 5km $\times$ Post-Fukushima	0.010 (0.031)	-0.041 (0.029)	-0.041** (0.019)		
operating NPP $<$ 5km $\times$ Post-Fukushima				-0.063** (0.029)	-0.058*** (0.017)
non-operating NPP $<$ 5km $\times$ Post-Fukushima				0.021 (0.044)	0.007 (0.032)
Month dummies	no	yes	yes	yes	yes
Zip code fixed effects	no	yes	yes	yes	yes
Property characteristics	no	no	yes	no	yes

NOTES: The endogenous variable is the log of the nominal house price posted. All regressions include a dummy for the post-Fukushima period. Regressions in columns (1) to (3) include a NPP dummy that indicates whether a house on offer is located within 5 km from a NPP site. In columns (4) and (5), we instead add separate NPP dummies for house near NPPs that were operating and non-operating right before the Fukushima accident. Property characteristics include age (and its square), a dummy for property still under construction, living space (and its square), base area (and its square), and a dummy for detached houses. The estimation sample comprises sales offers for single-unit detached and terraced houses houses posted on the internet platform ImmobilienScout24 in the months March 2009 to May 2012 (March 2011 offers are excluded). Sample size is $3,254,213$ (offer $\times$ month observations). The number of zip-code-level regional clusters is $9,276$. ***, **, * denote statistical significance at the 1%, 5%, and 10% level. Standard errors are clustered at the zip code level.

So far, our regression analysis may mask important differences in the treatment effect on houses near operating and non-operating NPPs. The NPP sites of Brunsbüttel and Krümmel had already been inoperative for several years before Fukushima (but retained the possibility to be re-connected to the grid in the future). Therefore, house prices in the vicinity of the two non-operating plants might already have reflected the possibility of a permanent closure before Fukushima. Consequently, columns (4) and (5) of Table 6 report separate treatment effects for houses near operating and non-operating NPPs (specification (4) does not and column (5) does control for property characteristics).

The differences are striking. Fukushima had no effect on house prices near non-operating NPPs. This result is consistent with the conjecture that local house prices already reflected the possibility of a permanent closure of these NPPs. In contrast, we do find large negative effects of Fukushima on the prices of houses located near NPPs that were operating before Fukushima. The most elaborate specification (5) suggests that asking prices of houses in the vicinity of an operating NPP site fell by 5.8% after the Fukushima accident. Therefore, real estate offered in the vicinity of operating NPP sites suffered a marked relative devaluation. In what follows, we take specification (5) as our baseline. For the sake of brevity, we do not report the (always insignificant) effects on houses near non-operating NPPs, but concentrate on the effect on houses near operating NPPs only.

The effects of the Fukushima accident on the housing market in Germany need not be confined to real estate within 5 km of an operating NPP site. If they are not, our control group of houses located at least 5 km away from a NPP site may be contaminated. To assess this possibility, we consider three further specifications. Column (1) of Table 3 reports treatment effects both for houses located less than 5 km from a NPP site and for houses located 5-10 km from a NPP site. The control group now consists of houses located at least 10 km away from a NPP site. Reassuringly, the treatment effect for houses in the immediate vicinity of a NPP remains at -5.8%. In contrast, houses located 5 to 10 km from a NPP site experienced only a small, and statistically insignificant, decrease in their offer prices (-1.4%). The treatment effect falls further (in absolute magnitude) when we consider property in locations even more distant from a NPP site, namely to -1.5%, -1.0% and -0.5% for house located 10-15 km, 15-20 km and 20-25 km, respectively, from a NPP site (see columns (2) to (4) of Table 3). These findings suggest that the impact of the Fukushima Daiichi accident on house prices in Germany was heavily concentrated, if not altogether confined to real estate in the immediate vicinity of NPP sites. Our choice of a 5 km cutoff for NPP_i therefore appears adequate. In what follows, we will maintain this threshold to define property within close range of NPP sites.

TABLE 3: TREATMENT EFFECTS BY DISTANCE TO NPP SITES

	(1)	(2)	(3)	(4)
Treatment effects:				
operating NPP $<$ 5km $\times$ Post-Fukushima	-0.058***	-0.059***	-0.059***	-0.059***
	(0.017)	(0.017)	(0.017)	(0.017)
5km $\leq$ operating NPP $<$ 10km $\times$ Post-Fukushima	-0.014	-0.014	-0.014	-0.014
	(0.009)	(0.009)	(0.009)	(0.009)
10km $\leq$ operating NPP $<$ 15km $\times$ Post-Fukushima		-0.015*	-0.015*	-0.015*
		(0.009)	(0.009)	(0.009)
15km $\leq$ operating NPP $<$ 20km $\times$ Post-Fukushima			-0.010	-0.010
			(0.007)	(0.007)
20km $\leq$ operating NPP $<$ 25km $\times$ Post-Fukushima				-0.005
				(0.006)

NOTES: The endogenous variable is the log of the nominal house price posted. The NPP dummies indicate whether a house on offer is located within 5 km, between 5 and 10 km, 10 and 15 km, 15 and 20 km or 20 and 25 km from a NPP site that was operating right before the Fukushima accident. Apart from these alternative distance measures and their respective interactions with the post-Fukushima dummy, property characteristics considered in these regressions are identical to those in Table 2. All regressions again include time dummies (month fixed effects) and zip-code fixed effects. Sample size in all regressions is $3,254,213$ (offer $\times$ month observations) and the number of zip-code-level regional clusters is $9,276$. ***, **, * denote statistical significance at the 1%, 5%, and 10% level. Standard errors are clustered at the zip code level.

4.2 Robustness checks

The key assumption for our difference-in-differences estimator to be unbiased is that asking prices of the treatment group (houses located within 5 km of a operating NPP site) and control group (houses located at least 5 km from a NPP site) would have followed the same time trend in the absence of the Fukushima accident. We corroborate this assumption in two ways. First, we restrict the estimation sample to a more homogeneous set of regions for which differential time trends may be less likely. Second, we directly test for differentials trends between treatment and control regions in the pre-Fukushima period.

The estimation results on various restricted estimation samples are reported in Table 4. Column (1) reproduces – from column (5) of Table 2 – the treatment effect for houses near operating NPPs of our baseline specification. In columns (2) and (3), we restrict the sample to property offers within 50 km and 25 km, respectively, of NPP sites.[20] For property offers within 50 km of NPP sites the estimated treatment effect turns out to be identical to our baseline estimate (-5.8%); and for property offers within 25 km of NPP sites, it shrinks only slightly in absolute magnitude to -5.1% (see columns (2) and (3) of Table 4). As a further check, we exclude all offers from Germany's 25 largest cities.[21] Again, the estimated treatment effect (now -5.3%) differs only little from our baseline estimate (column (4)). Excluding urban city districts from the estimation sample (column (5)), or cities with more than 100,000 inhabitants (column (6)), also does not materially affect the estimated treatment effect.

Next, we directly test for differences in pre-treatment trends between the treatment and control group (see Table 5). To do so, we first add a linear time trend and its interaction with our NPP dummy to the set of regressors. As shown in column (2), however, there is no evidence that linear price trends differed between real estate close to NPP sites and real estate further away from such sites. Our point estimate of the treatment effect also remains negative, large, and statistically significant (-7.0%). We next add three leads of the treatment effect to the regression specification. Specifically, we interact dummies for the months $1-6$, $7-12$, and $13-18$ before the Fukushima Daiichi accident with the NPP dummy. Reassuringly, all three leads of the treatment effect are statistically insignificant (see column (3) of Table 5). We thus find no evidence that offer prices of the treatment and control group followed different trends before the Fukushima Daiichi accident. Moreover, the treatment effect remains statistically significant at -4.6%. The lack of evidence for a differential pre-Fukushima trend also suggests that the September 2010 decision of the government to extend maximum remaining operation times of German NPPs had no effect on real estate prices in the vicinity of NPP sites. Finally, we explore whether the treatment effect changed over time after the treatment. To do so, we split the post-Fukushima sample in two periods of seven months each. The result in column (4) suggests that the treatment effect changed little over the two periods (-5.5% vs. -6.2%). Finally, we add lead and lag indicators at the same time (see column (5)). Figure 2 illustrates the findings of

[20] In these restricted estimation samples, property offers from East Germany (which has no NPP sites) are virtually zero, and the share of property offers from bigger cities is significantly reduced. 14.8% of all observations in our unrestricted estimation sample are from East Germany (including Berlin). This figure falls to 0.2% and 0.1% if we restrict the estimation sample to property offers within 50 km and 25 km, respectively, of NPP sites. 12.3% (5.8%) of all observations in our unrestricted estimation sample are from Germany's 25 (5) largest cities. This figure falls to 9.3% (4.3%) if we restrict the estimation sample to property offers within 50 km of NPP sites. It falls further to 3.8% (1.2%) if we restrict the estimation sample to property offers within 25 km of NPP sites.

[21] Each of these cities has more than $250,000$ residents. Four cities have more than one million inhabitants (Berlin, Hamburg, Munich, Cologne).

TABLE 4: ROBUSTNESS CHECKS I: REGIONAL AND POPULATION-BASED RESTRICTIONS ON ESTIMATION SAMPLE

	(1)	(2)	(3)	(4)	(5)	(6)
Treatment effect:						
operating NPP < 5km ×						
Post-Fukushima	-0.058***	-0.058***	-0.051***	-0.053***	-0.052***	-0.051***
	(0.017)	(0.016)	(0.016)	(0.017)	(0.018)	(0.017)
Estimation sample:						
Property < 50km from NPP	no	yes	no	no	no	no
Property < 25km from NPP	no	no	yes	no	no	no
Excl. 25 most populous cities	no	no	no	yes	no	no
Excl. city districts	no	no	no	no	yes	no
Excl. cities > 100k residents	no	no	no	no	no	yes
Observations	3,254,213	989,645	292,451	2,855,534	2,614,743	2,630,084

NOTES: The endogenous variable is the log of the nominal house price posted. To ease comparison, column (1) reproduces – from column (5) of Table 2 – the treatment effect of our baseline specification. The NPP dummy indicates whether a house on offer is located within 5 km from a NPP site that was operating right before the Fukushima accident. All regressions include time (month fixed effects), NPP and post-Fukushima dummies, zip-code fixed effects, and property characteristics (see notes to Table 2). Estimates reported in columns (2) to columns (6) are based on restricted estimation samples. Column (2) reports estimates for property within 50km of a NPP site, and column (3) for property within 25km of a NPP site. Column (4) estimates are based on a restricted estimation sample that excludes property offers from the 25 most populous cities in Germany. The estimation sample for column (5) excludes property from city districts, and the estimation sample for column (6) excludes property from cities with more than 100,000 inhabitants. The number of zip-code level regional clusters is $9,276$ in specification (1), $3,019$ in specification (2), 999 in specification (3), $8,371$ in specification (4), $7,842$ in specification (5), and $7,880$ in specification (6). ***, **, * denote statistical significance at the 1%, 5%, and 10% level. Standard errors are clustered at the zip code level.

this regression graphically.

We also conduct several other tests to assess the robustness of our main finding. The results of these tests are reported in Table A-2 in the Appendix. First, we restrict the estimation sample to those sales offers that are newly posted (inflow sample) instead of considering all offers in a given month (stock sample). The price of new offers may respond more quickly to changes in local (dis-)amenities and may therefore more accurately reflect changes in local conditions. Excluding old offers leaves us with $797,340$ observations, a fourth of our overall sample size, but does not change our estimate of the treatment effect (see column (2) of Table A-2). Second, we drop all observations from the four-month period March to June 2011. Restricting the estimation sample in this way provides for a clear divide between sales offers before Fukushima (March 2009 to February 2011) and sales offers after the post-Fukushima change in Germany's energy policy (July 2011 to May 2012). With the parliament's decision on 30 June 2011, future operating and closure times of individual NPPs were fixed and any uncertainty on the future of individual NPPs resolved. As it turns out, however, the estimate of the treatment effect is not affected by this change in the estimation sample either (column (3)). Third, we use municipality fixed effects instead of zip code region fixed effects. The use of these political-administrative clusters, which are more numerous than zip code regions ($13,759$ instead of $9,276$ in our baseline estimation sample), also does not change our results markedly (column (4)). The same holds true if we use district fixed effects, i.e., larger political-administrative regional clusters (column (5)).

TABLE 5: ROBUSTNESS CHECKS II: LINEAR TIME TREND, TREATMENT LEADS AND LAGS

	(1)	(2)	(3)	(4)	(5)
Lags:					
NPP $<$ 5km $\times$ Post-Fukushima	-0.058*** (0.017)	-0.070*** (0.022)	-0.046** (0.019)		
NPP $<$ 5km $\times$ Fukushima$_{t+2}$				-0.062*** (0.020)	-0.049** (0.021)
NPP $<$ 5km $\times$ Fukushima$_{t+1}$				-0.055* (0.019)	-0.042* (0.023)
Leads:					
NPP $<$ 5km $\times$ Fukushima$_{t-1}$			0.011 (0.019)		0.011 (0.019)
NPP $<$ 5km $\times$ Fukushima$_{t-2}$			0.030 (0.023)		0.030 (0.023)
NPP $<$ 5km $\times$ Fukushima$_{t-3}$			0.007 (0.015)		0.007 (0.015)
Time Trend:					
NPP dummy $\times$ linear time trend		0.0006 (0.0009)			

NOTES: The endogenous variable is the log of the nominal house price posted. To ease comparison, column (1) reproduces – from column (5) of Table 2 – the treatment effect of our baseline specification. The NPP dummy indicates whether a house on offer is located within 5 km from a NPP site that was operating right before the Fukushima accident. All regressions include time (month fixed effects), NPP and post-Fukushima dummies, zip-code fixed effects, and property characteristics (see notes to Table 2). Specification (2) adds a linear time trend and its interaction with the NPP dummy to the set of regressors. In specifications (3) and (5), the NPP dummy is interacted with time dummies that divide the 18 months period before Fukushima in three periods of six months each. In specifications (4) and (5), the NPP dummy is interacted with time dummies that divide the 14 months period after Fukushima in two periods of seven months each. Sample size in all regressions is again $3,254,213$ (offer $\times$ month observations) and the number of zip-code-level regional clusters is $9,276$. ***, **, * denote statistical significance at the 1%, 5%, and 10% level. Standard errors are clustered at the zip code level.

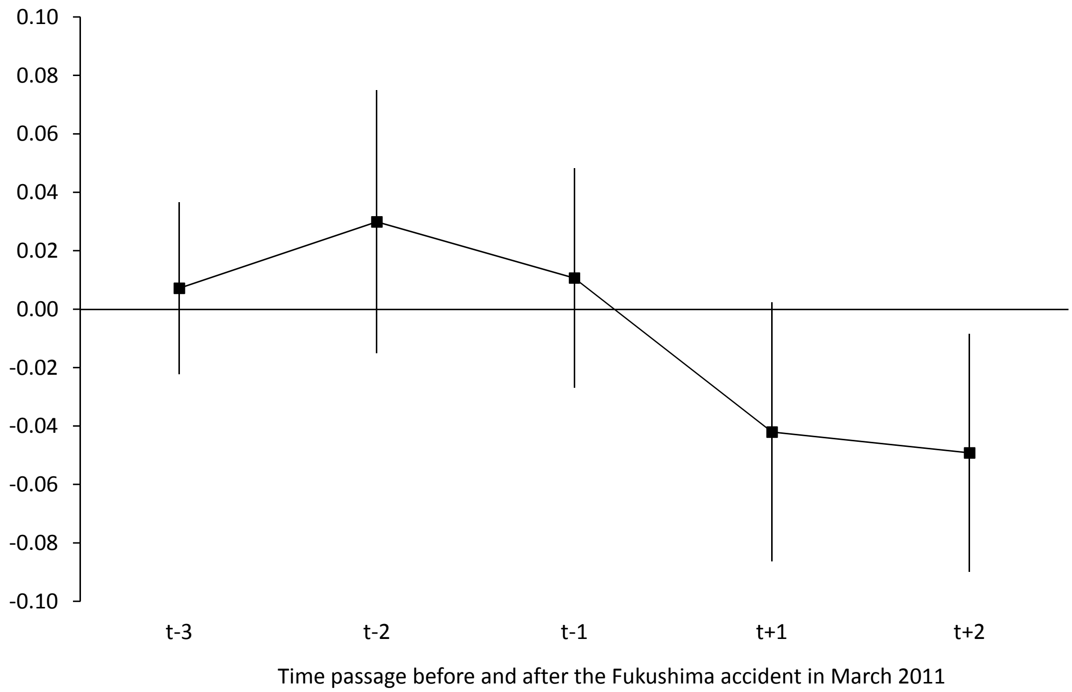
4.3 Heterogenous treatment effects

We have seen that the effect of Fukushima on house prices near NPP sites depends on the operation status of sites before the accident. Prices of houses near operating NPPs fell significantly after Fukushima, whereas houses near inactive NPPs suffered no loss in value after the accident (column (1) of Table 6 reproduces this result). However, the effect of Fukushima on local house prices may not only depend on the pre- but also on the post-Fukushima operation status of NPP sites. After the Fukushima accident, NPP sites Biblis and Unterweser were closed immediately. At all other sites that were in operation before the accident, at least one block was allowed to stay in operation (although maximum operation times were cut back).

Whether a NPP site was closed immediately after Fukushima is likely to be of great importance for the local housing market. At least in the short run, adverse economic effects should be larger near sites that were closed after Fukushima – and the local fall in house prices therefore more pronounced. At the same time, however, site closures also reduce substantially the risk of a nuclear accident. If the documented negative effect of Fukushima on house prices were mainly due to updated risk perceptions, the effect should be much smaller near sites that were closed after the accident (see Section 2.2).

In an additional regression, we therefore distinguish not only between houses near non-operating and operating NPPs, but also among the latter group between houses near sites that were closed and that were

FIG. 2: GRAPHICAL REPRESENTATION OF TREATMENT LEADS AND LAGS



Notes: Plotted estimates are from column (5) of Table 5. The point estimates are marked by a dot. The vertical bands indicate the 95% confidence interval of each estimate.

not closed after Fukushima. The results of this regression are reported in column (2) of Table (6). As is evident, Fukushima decreased the price of houses located next to NPP sites which were operating before Fukushima but closed shortly after the accident by as much as 10.8%. In contrast, for houses near operating sites which were not closed immediately after the accident, the fall in prices is considerably smaller in magnitude (−4.6%), but still significant. Finally, and as before, we find that Fukushima had no statistically significant effect on house prices near NPP sites which were inactive at the time of the accident.

These results suggest that economic reasons are of prime importance for the deterioration of offer prices in the vicinity of NPP sites. The economic effects of the nuclear phase-out, of course, will only unfold over time. However, they are likely to be anticipated by market participants. Data on actual local economic outcomes are, unfortunately, not yet available for 2012. However, municipality-level data[22] from 2010 and 2011 tentatively suggest that the economic effects could already be felt in 2011 – in particular at sites which were closed completely after Fukushima.

As shown in column (1) of Table 7, municipalities with a NPP site that was closed after Fukushima experienced a population loss of 0.6% between the end of 2010 and the end of 2011 (relative to municipalities without a NPP). No such effect can be observed for municipalities with a non-operating NPP and for

[22]The data come from the statistical offices of the German Länder and the Federal Statistical Office.

TABLE 6: HETEROGENOUS TREATMENT EFFECTS: TREATMENT EFFECTS BY CLOSURE TYPE

	(1)	(2)
Treatment effects:		
Operating NPP $<$ 5km $\times$ Post-Fukushima	-0.058***	
	(0.017)	
Operating NPP, closed $<$ 5km $\times$ Post-Fukushima		-0.108***
		(0.018)
Operating NPP, not closed $<$ 5km $\times$ Post-Fukushima		-0.046**
		(0.020)
Non-operating NPP $<$ 5km $\times$ Post-Fukushima	0.007	0.007
	(0.032)	(0.032)

NOTES: The endogenous variable is the log of the nominal house price posted. The NPP dummies indicate whether a house on offer is located within 5 km from a NPP site that was either operating or not operating before the Fukushima accident. Among the operating NPP sites, we further distinguish between those sites that were fully closed after Fukushima and those that were not. All regressions include time dummies (month fixed effects), the respective NPP dummies, property characteristics, and zip-code fixed effects. ***, **, * denote statistical significance at the 1%, 5%, and 10% level. Standard errors are clustered at the zip code level.

TABLE 7: OTHER OUTCOMES: DID ESTIMATES AT MUNICIPALITY LEVEL

	(1)	(2)	(3)
Municipality with...	Population	Employment	Overnight stays
operating NPP, closed $\times$ Post-Fukushima	-0.006***	-0.011***	-0.244***
	(0.002)	(0.002)	(0.010)
operating NPP, not closed $\times$ Post-Fukushima	-0.002	-0.008	-0.061**
	(0.004)	(0.009)	(0.026)
non-operating NPP, closed $\times$ Post-Fukushima	-0.001	-0.005**	-0.058**
	(0.007)	(0.003)	(0.024)
Municipality with NPP dummy	yes	yes	yes
Federal state dummies	yes	yes	yes
2011 dummy	yes	yes	yes
N	10,994	10,978	5,187

NOTES: The endogenous variable is the log of population (column 1), the log of total employment (column 2), and the log of the number of overnight stays (column 3) in a municipality. Among the operating NPP sites, we further distinguish between those sites that were fully closed after Fukushima and those that were not. All regressions include a time dummy (indicator for 2011), dummies for municipalities with a NPP, and federal state dummies. The sample consists of all municipalities in West Germany. ***, **, * denote statistical significance at the 1%, 5%, and 10% level. Standard errors are clustered at the municipality level.

municipalities with an operating NPP that was not closed after Fukushima. People may leave or not move to a municipality if local economic conditions, particularly on the labor market, deteriorate or are expected to deteriorate in the future. Data on actual employment is currently only available until 30 June 2011. Nevertheless, we do find that employment in municipalities with an operating NPP site that was closed after Fukushima decreased by 1.1% between mid-2010 and mid-2011 (relative to municipalities without a NPP). The difference to the employment trend in municipalities without a NPP is not statistically significant for municipalities with an operating NPP site which was not closed after the accident, and it is smaller for municipalities with a non-operating NPP (-0.5%).[23] The closure of reactors after Fukushima also severely

[23]Municipalities with already inoperative NPP sites might still experience adverse economic trends if the effects unfold over

affected local hotels, which regularly accommodate engineers and assembly operators from subcontracting firms. Overnight stays in Stadland, for instance, the municipality that hosts the closed NPP site of Unterweser, decreased from 21,041 in 2010 to 17,528 in 2011. Data for Biblis, the second site which was closed after Fukushima, are missing, but reports from local newspapers suggest that the local hotel and restaurant industry already suffers greatly from the closure.[24] Negative effects are also visible, but much smaller, for municipalities with NPP sites that are still operating or that were already inactive before Fukushima (see column (3) of Table 7).

5 Conclusion

The nuclear accident at Fukushima on 11 March 2011 caused a fundamental change in Germany's energy policy. Within days of the accident, the German government decided to temporarily close eight of 17 nuclear reactors. In June 2011, the government made the closure permanent, and also declared the phasing out of Germany's remaining nine NPPs by 2022. This paper shows that the nuclear disaster in distant Japan – and the U-turn in Germany's energy policy it caused – has large adverse effects on house prices near German NPPs. Using data from Germany's largest internet platform for real estate, we show that house prices near NPPs that were operating at the time of the Fukushima disaster fell by almost 6% after the disaster.

We argue that adverse economic effects of the nuclear phase-out are the prime reason for the observed fall in houses prices. NPP sites do not only employ a considerable number of workers. They also benefit local subcontracting firms, increase local overnight stays, and generate business tax revenues. The unexpected nuclear phase-out is therefore likely to hit local economies hard. Adverse economic effects should, at least in the short run, be largest in regions where a NPP site was closed immediately. If adverse economic effects can indeed explain the negative effect of Fukushima on house prices, we would expect the fall in house prices to be largest near sites that were closed after the accident. Consistent with this conjecture, we find that house prices near such sites fell by as much as 11% after the Fukushima disaster.

time.

[24]See, for instance, the online articles in *Frankfurter Rundschau* on 2 October 2012 ("Eine Stadt sucht ihre Zukunft").

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A Appendix

TABLE A-1: NUCLEAR POWER PLANTS (NPPS) AND NPP SITES IN GERMANY

	NPP	NPP	NPP	NPP in operation	Post-Fukushima NPP shut down:		NPP background/technical features:		
	name	site	state	(March 2011)	temporary[1]	permanent[2]	operating since[3]	reactor type	capacity (MWe)
1.	Biblis-A	1	HE	yes	yes	2011 / 08 / 06	1974	PWR	1,225
2.	Biblis-B	1	HE	yes	yes	2011 / 08 / 06	1976	PWR	1,300
3.	Brokdorf	2	SH	yes	no	2021 / 12 / 31	1986	PWR	1,480
4.	Brunsbüttel[4]	3	SH	no	yes	2011 / 08 / 06	1976	BWR	806
5.	Emsland	4	NI	yes	no	2022 / 12 / 31	1988	PWR	1,400
6.	Grafenrheinfeld	5	BY	yes	no	2015 / 12 / 31	1981	PWR	1,345
7.	Grohnde	6	NI	yes	no	2021 / 12 / 31	1984	PWR	1,430
8.	Gundremmingen-B	7	BY	yes	no	2017 / 12 / 31	1984	BWR	1,344
9.	Gundremmingen-C	7	BY	yes	no	2021 / 12 / 31	1984	BWR	1,344
10.	Isar-1	8	BY	yes	yes	2011 / 08 / 06	1977	BWR	912
11.	Isar-2	8	BY	yes	no	2022 / 12 / 31	1988	PWR	1,485
12.	Krümmel[4]	9	SH	no	no	2011 / 08 / 06	1983	BWR	1,402
13.	Neckarwestheim-1	10	BW	yes	yes	2011 / 08 / 06	1976	PWR	840
14.	Neckarwestheim-2	10	BW	yes	no	2022 / 12 / 31	1988	PWR	1,400
15.	Philippsburg-1	11	BW	yes	yes	2011 / 08 / 06	1979	BWR	926
16.	Philippsburg-2	11	BW	yes	no	2019 / 12 / 31	1984	PWR	1,468
17.	Unterweser	12	NI	yes	yes	2011 / 08 / 06	1978	PWR	1,410

NOTE: [1] Temporary shut downs during the 3-month moratorium were announced on 14 March 2011 and took effect within three to four days. [2] The German federal government announced on 30 May 2011 the list of NPPs that were to be closed permanently and the remaining operation times of NPPs that were to remain active. All of the NPPs that were temporarily shut down during the moratorium had to shut down permanently. These measures took effect on 6 August 2011. None of the NPPs temporarily shut down during the moratorium, and neither Brunsbüttel and Krümmel, resumed operation between the end of the moratorium in mid June and 6 August 2011. [3] Date of initial criticality (Department of Nuclear Safety, 2011). [4] NPPs Brunsbüttel and Krümmel had been inactive since the summer of 2007, except for one short-time operation of Krümmel in June 2009 (Department of Nuclear Safety, 2011, 2012). BW=Baden-Wuerttemberg, BY=Bavaria, HE=Hesse, NI=Lower Saxony, SH=Schleswig Holstein. BWR=Boiling water reactor. PWR=Pressurised water reactor.

TABLE A-2: ROBUSTNESS CHECKS III: NEW OFFERS, PRE- AND POST-MORATORIUM PERIOD, REGIONAL CLUSTERS

	(1)	(2)	(3)	(4)	(5)
Treatment effect:					
NPP < 5km × Post-Fukushima	-0.058***	-0.058***	-0.059***	-0.062***	-0.060***
	(0.017)	(0.022)	(0.018)	(0.018)	(0.021)
Type of offers	all	new offers	all	all	all
Sample incl. 04-06/2011	yes	yes	no	yes	yes
Regional fixed effects	zip code	zip code	zip code	municipality	district
Observations	3,254,213	797,340	3,017,692	3,254,213	3,254,213

NOTES: The endogenous variable is the log of the nominal house price posted. To ease comparison, column (1) reproduces - from column (5) of Table 2 - the treatment effect of our baseline specification. The NPP dummy indicate whether a house on offer is located within 5 km from a NPP site that was operating right before the Fukushima accident. All regressions include time (month fixed effects), NPP and post-Fukushima dummies, regional fixed effects, and property characteristics (see notes to Table 2). Column (2) reports estimates for a restricted estimation sample, in which only sales offers are considered that are newly posted in a given month (inflow sample). Column (3) reports estimates for a restricted sample, in which all observations from the four-month period March to June 2011 are dropped. Columns (4) and (5) report results when using municipality and district fixed effects, respectively, instead of zip code fixed effects. The number of zip-code level regional clusters is $9,276$ in specification (1), $9,084$ in specification (2), and $9,262$ in specification (3). The number of municipality level regional clusters in specification (4) is $13,759$ and the number of district level regional clusters in specification (5) is 418. ***, **, * denote statistical significance at the 1%, 5%, and 10% level. Standard errors are clustered at the level of the regional fixed effects.