Accepted Manuscript

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Michihito Ando, Matz Dahlberg, Gustav Engström

PII: S0165-1765(17)30062-9
DOI: http://dx.doi.org/10.1016/j.econlet.2017.02.017
Reference: ECOLET 7513

To appear in: *Economics Letters*

Received date: 27 September 2016
Revised date: 20 December 2016
Accepted date: 8 February 2017

*Highlights (for review)

- We explore the potential effect of the Fukushima disaster on housing prices in Sweden.
- We use data set on housing sales transactions in vicinity of nuclear power plants in Sweden.
- We do not find any disproportionate effect from the Fukushima disaster on housing prices.

*Title Page

The Risks of Nuclear Disaster and Its Impact on Housing Prices*

Michihito Ando† Matz Dahlberg‡ Gustav Engström§

December 20, 2016

Abstract

Using a data set on housing sales transactions we explore the potential effect of the Fukushima disaster on housing prices in Sweden. In contrast to most earlier findings in other countries we do not find any disproportionate effect from the Fukushima disaster on housing prices in vicinity of nuclear power plants in Sweden.

Keywords: Fukushima, Nuclear accident, housing price, difference-in-differences
JEL codes: Q51, Q53, R21

*A research grant from Handelsbankens Forskningsstiftelser (P2013-0081:1) is gratefully acknowledged.

†National Institute of Population and Social Security Research, Japan. Hibiya Kokusai Building 6th Floor 2-2-3 Uchisaiwai-cho, Chiyoda-ku, Tokyo 100-0011, Japan. andou-michihito@ipss.go.jp

‡Institute for Housing and Urban Research and Department of Economics, Uppsala University, Sweden. matz.dahlberg@ibf.uu.se

§The Beijer Institute of Ecological Economics, at the Royal Swedish Academy of Sciences, Stockholm, Sweden. gustav.engstrom@beijer.kva.se

1 Introduction

In this paper, we use data on individual real estate transactions from the Swedish housing market in order to study whether the Fukushima Daiichi nuclear disaster on March 11, 2011, affected housing prices in the vicinity of nuclear power plants.

The Fukushima accident was big news all over the world, and previous research provides evidence that the Fukushima incident has indeed had an impact on public opinion polls as well as a significant reduction in reported well-being in various countries (Holmberg, 2012; Goebel et al., 2015). The immediate response in most countries was a reduced public support for existing and future proposed plants: The reduced support for nuclear energy was largest in Japan and its surrounding Asian neighbors. Outside Asia, Germany was one of the countries where public opinions were most negatively affected, while the effect on public opinion in the USA and the UK was negligible (Holmberg, 2012). According to public polls conducted in Sweden, the support for nuclear power dropped immediately after the Fukushima accident by 17% and 20%, respectively, compared to earlier polls done in 2010 and 2008 (Holmberg, 2012). An interesting question is thus whether this increase in the awareness of the risks of nuclear disaster has also capitalized onto the housing markets.

Several recent studies have provided quasi-experimental evidence that this may in fact be the case in many countries, e.g. Bauer et al. (2014) for Germany, Boes et al. (2015) for Switzerland, and Zhu et al. (2016) for China[1], while Fink and Stratmann (2015) do not find such an effect in the US. They all exploit the Fukushima nuclear accident as an exogenous shock to local housing or land markets and adopt difference-in-differences (DID) approaches to estimate the impact of the accident on housing or land prices near nuclear plants.

Due to explicit quasi-experimental frameworks, these studies may not suffer from serious endogeneity problems, but other problems still exists. Bauer et al. (2014) and Fink and Stratmann (2015) rely on data attained

[1]Boes et al. (2015) find that the Fukushima accident led to a 2.3% price discount on apartment rents in the vicinity of nuclear power plants in Switzerland. Bauer et al. (2014) find a price discount of up to 5% on real estate located near nuclear plants in Germany. Zhu et al. (2016) find that land prices near nuclear plants decreased by around 18% one month after the accident but that this initial impact decays over time.

from public internet platforms where the data source is either approximate or proxies underlying transactions.[2] Using sources such as these thus reduces the precision of estimated values of marginal willingness to pay and may in a worst case scenario lead to biases due to measurement error. The study by Boes et al. (2015) uses data from the rental market also attained from a public internet platform.[3] Apart from being sensitive to divergences between the actual "final" negotiated rent and the announced rent, the rental market may also suffer from more government price manipulation in form of subsidies than ownership housing.[4] Finally, Zhu et al. (2016) examine land markets in China with micro-level transaction data, but they do not directly investigate housing markets. In addition, local governments are the only legitimate sellers in urban land markets in China. Hence the findings of Zhu et al. (2016) may not easily generalize to housing transactions in other countries.

Our study is, to our knowledge, the first to use individual level housing sales transactions to assess the effect of the Fukushima accident on property values in the vicinity of nuclear power plants. We use a DID method and find that the accident did not have a disproportionate effect on property prices in the vicinity of plants; the obtained point estimates are tightly and robustly estimated zeros.

2 Data and empirical strategy

2.1 Data

We use a data set consisting of approximately 80% of all individual transactions of houses and apartments in Sweden covering the period 2010-2012. Each transaction typically contains information on the list price and the final sales price, size/area, number of rooms, plot size, number of floors, construction year, rents as well as geographical coordinates and address information. As a quality control of the data we also geocoded the address to

[2] Bauer et al. (2014) rely on data from the website ImmobilienScout24 which only records asking as opposed to transaction prices. Fink and Stratmann (2015) uses approximate values from the Zillow website (U.S), including not only house sale prices but also assessment values.

[3] They use data from the Homegate, the largest online advertising platform for rental apartments in Switzerland.

[4] In Switzerland, housing subsidies are granted by the federal government as well as various cantons and municipalities in the rental market (Schneider and Wagner, 2015).

avoid any potential data insertion errors. In addition, we know the exact dates when the objects came on the market and when they were sold. This is important for being able to determine whether an object is considered as treated or not (i.e., whether it was sold before or after March 11, 2011).

To our knowledge, we are the first to study the effect of the Fukushima nuclear disaster using directly reported housing sale transactions. In comparison to earlier studies, the analysis undertaken here is thus less prone to biases as a result of poor data quality. Also, prices on the Swedish housing markets are unregulated in the sense that demand is not skewed due to price regulations or subsidies.

While Table 1 shows some descriptive statistics for our sample categorized by housing type and distance from nuclear plants, Figure 1 shows price trends for the same categories. The pattern observed in both graphs in Figure 1 indicates that the important assumption in a DID-framework of common time trends appears to be valid; the price trends seem to be fairly before March 2011 irrespective of housing type and distance to nuclear power plant.[5] Figure 2 shows the area from which we select the observations that are to be investigated.

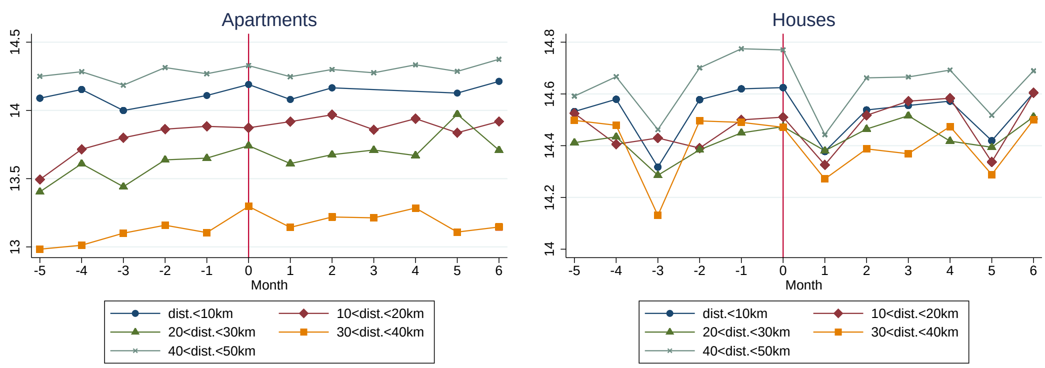
[5] In the empirical analysis, the common trend assumption will be further examined, through the placebo results, in which pre-accident common trends are checked conditional on the covariates.

Table 1: Descriptive statistics - means and standard deviations

Distance from a plant	$0 \sim 50km$	$0 \sim 10km$	$10 \sim 20km$	$20 \sim 30km$	$30 \sim 40km$	$40 \sim 50km$
Apartments						
Contract price (SEK)	1,709,557	945,488	1,184,131	1,213,819	826,721	1,878,351
	(1,128,683)	(387,855)	(580,033)	(807,545)	(785,332)	(1,139,847)
Living area (m^2)	69	73.8	73.9	75.5	74.1	67.6
	(26.5)	(15.9)	(25.4)	(21.8)	(22.5)	(27.2)
Number of rooms	2.5	2.5	2.64	2.78	2.75	2.44
	(1.04)	(.833)	(1.13)	(.966)	(1.05)	(1.03)
Monthly fee (SEK)	3,588	3,275	3,716	4,081	3,918	3,498
	(1,255)	(782)	(1,383)	(1,316)	(1,252)	(1,227)
Sample size	12871	32	428	1027	1106	10278
Houses						
Contract price (SEK)	2,600,454	1,941,525	2,337,265	2,215,261	2,353,949	2,966,695
	(1,797,922)	(1,191,773)	(1,372,845)	(1,266,289)	(1,722,697)	(2,032,249)
Living area (m^2)	122	101	119	116	121	127
	(46.3)	(47.1)	(49.4)	(46.6)	(45.8)	(44.9)
Number of rooms	4.94	4.25	4.77	4.69	4.85	5.16
	(1.57)	(1.43)	(1.58)	(1.58)	(1.5)	(1.57)
Plot area (m^2)	9,685	15,554	6,841	9,431	3,288	10,142
	(4,665)	(4,675)	(.)	(3,047)	(1,539)	(4,245)
Sample size	9643	336	1033	1632	2139	4503

Note: Standard deviations are in parenthesis. Monthly fee is a charge imposed by the co-op in which an apartment is located. SEK means Swedish Krona. The sample period is from January 12 2010 to December 11 2012 because, in the subsequent analysis, we construct monthly and quarterly data using 12th as the first date of a month.

Figure 1: Time trends by distance



Note: The vertical line at time point zero indicates when the Fukushima accident took place.

Figure 2: Locations of active nuclear power plants in Sweden.

Note: The circles feature a 50 km radius covering the locations included in the sample.

2.2 Empirical strategy

To examine the effects of the Fukushima disaster on housing prices in Sweden, we adopt a DID approach using a distance from a nuclear plant as an indicator of treatment intensity. We thus compare housing prices close to and further away from the power plants before and after the Fukushima disaster on March 11, 2011.

The model specification is a semi-log hedonic price function that takes the following form:

$$Y_{it} = \alpha Dist_i + \sum_{\tau \neq 0} \beta_\tau Dist_i \times 1[t=\tau] + \gamma 1[t=\tau] + \mathbf{X}'_{it}\theta + \sigma_s + \varepsilon_{it} \qquad (1)$$

where Y_{it} is the log of the selling price, $Dist_i$ is the continuous distance (in meters) from each house i to the closest nuclear power plant, $1[t=\tau]$ is a dummy variable that takes the value of one if $t=\tau$ and zero otherwise (t is measured either by quarter or by month), $\mathbf{X}'_{it}$ contains the control variables listed in Table 1, and σ_s is the spatial fixed effect that is meant to capture some area-specific common shocks in area s. In order to remove confounding idyosyncratic spatial shocks but to leave out sufficient within-area variation caused by the Fukushima accident if it exists, we use congregation-level spatial fixed effect for σ_s in our analysis.

The coefficients of interest are the time varying coefficients β_τ of the interaction term, $Dist_i \times 1[t = \tau]$; before March 11, 2011, β_τ can be seen as placebo-estimates and after March 11, 2011, β_τ can be seen as effects of the Fukushima accident. We estimate equation (1) using fixed-effect regressions where the standard errors are clustered by area s.[6]

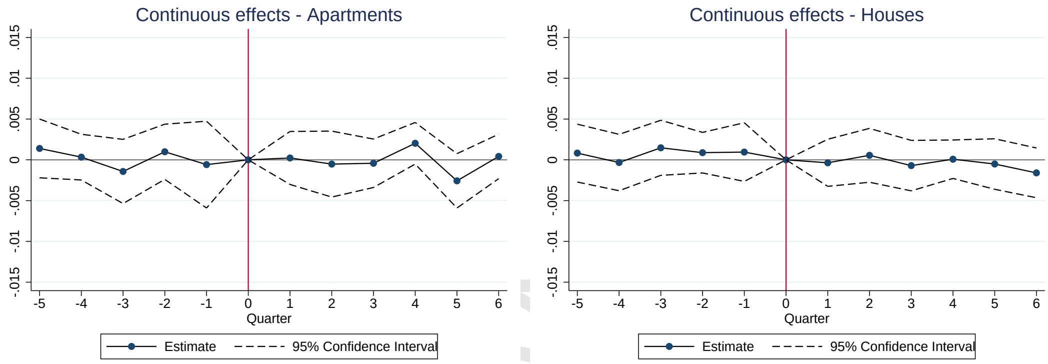
3 Results

Estimating equation (1) separately with quarterly data for apartments (upper left figure in Figure 3) and houses (upper right figure in Figure 3) we get very similar results. First, as is visible from the pre-accident estimates in both the upper figures in Figure 3, the placebo estimates indicate that we have a credible model specification; all the estimates are statistically insignificant and the point estimates are rather precisely estimated at zero (indicating that the common trends assumption is indeed valid). Second, as is clear from the post-accident estimates, the Fukushima disaster seems to have had no significant effects on the prices of houses or apartments close to nuclear power plants in Sweden; also after March 11, 2011, are the estimates statistically insignificant and the point estimates are precisely estimated at zero. Finally, conducting the analyses on monthly data yields the same conclusion (see the two lower figures in Figure 3).

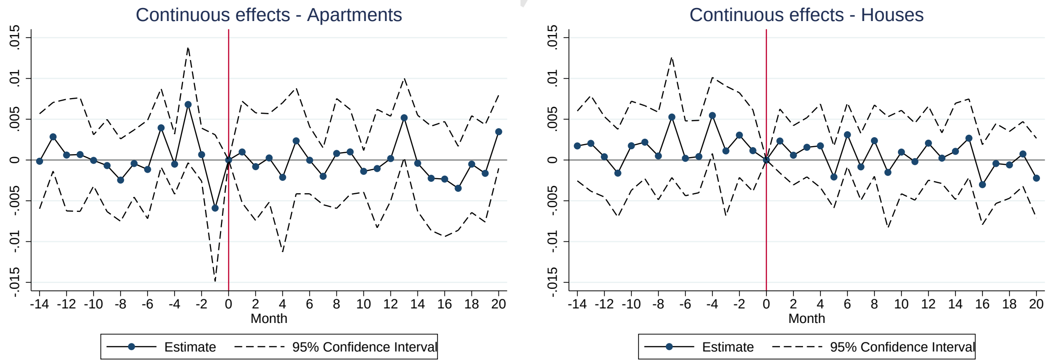
[6] We have also estimated some variants of equation (1) by dropping spatial fixed effects σ_s or replacing spatial fixed effects σ_s with municipality-level fixed effects. We have also estimated a model with a time-invariant coefficient β instead of β_τ in equation (1), as well as DID-models using discrete cut-offs at different distances from the nuclear power plants (i.e. discretely splitting the group into "treated" and "untreated", allowing for group-specific time trends). These different specifications do not yield any meaningful differences in our estimation results. All these additional estimation results are available from authors upon request. Regarding the specifications with discrete cut-offs, it shall be noted that, first, there is no natural cut-off in the Swedish case in the sense that there is no public statement from the government in Sweden on what distance from a nuclear power plant that would constitute a risk zone (as in Boes et al. (2015)), and, second, for apartments within very small distances from the nuclear power plants, we get a small treatment sample size.

Figure 3: Time-varying estimates: Continuous treatment

(a) Quarterly data



(b) Montly data



Note: The vertical line at time point zero indicates when the Fukushima accident took place. Solid lines indicate point estimates of β_τ based on equation (1) and dashed lines indicate 95% confidence intervals estimated by clustered robust standard errors. The number of clusters (congregation areas) are 64 for apartments and 124 for houses.

4 Conclusions

Using individual transactions on houses and apartments from the Swedish housing market with exact information on, among other things, final prices and dates when sold and when entering the market, we cannot detect any effects of the Fukushima Daiichi nuclear disaster on housing prices in the vicinity of power plants. Our estimates are precisely estimated zeros, and our placebo estimates indicate that we have reliable model specifications.

This result is interesting for at least three reasons. First, even though there was an increased uncertainty and decreased support for nuclear power in public polls in Sweden (see Holmberg, 2012), these stated preferences do not spill over to revealed behavior (as observed in the housing market). Second, since most earlier studies on data from other countries have found statistically significant (negative) effects on property values close to nuclear power plants, our results show that an increased risk after the Fukushima accident is not universally perceived. Third, since the exact information in our housing price data helps insulate us from approximation errors inherent in the housing price measures used in previous studies, it is also an open question whether an effect would have been found for the other countries had they had access to equally detailed data as we have.

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