Nuclear Power Plants and Housing Prices

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Abstract:

We examine the effects of the Fukushima crisis on housing prices in Plymouth, Massachusetts. This study challenges the perception on how natural disasters effect property value. We set out to measure the interaction between distance from a nuclear power plant and housing prices, before and after 2011. We find a 2.4% decrease in house prices moving away from the plant. Additionally, we see a 2.6% decrease in house prices relative to distance, after the Fukushima crisis.

I. Introduction

A great deal of attention has been conducted about the safety of nuclear power. There has been a talk about a given nuclear renaissance that will make power plants more economically feasible, and better methods of generating electricity. Interests include, lowering carbon emission, improvement and performance of generators, and ultimately reducing the usage of fossil fuels. However, people's view on nuclear energy has always been negative, and any construction in the U.S. of new power plants, in the 21st century, have been stagnant. On March 2011, a tsunami caused damage to a nuclear reactor in Fukushima Daiichi, Japan. This led to a radiation leak that ultimately caused an evacuation of the residence nearby.

In this paper, we set out to measure how disasters, in particular nuclear disasters, change people's beliefs about the risk of a major event. In particular, we measure how house prices around a power plant, located in Plymouth, Massachusetts changed after 2011, when an earthquake hit Japan. The Fukushima accident was well covered by U.S. media and also led to evaluations of nuclear energy among the public. Chart 1 shows the popularity of the word Fukushima in Plymouth during a 5-year period after the accident.

Plymouth, Massachusetts is a special case because not only is a nuclear power plant located in a very popular area, but also because the power plant has been decommissioned in 2019. In this paper, we study the effect of the Fukushima disaster on housing prices, in Plymouth. We identify the effects of distance from a nuclear power plant, and the overall individual house price of a single-family home. We also conduct a proper region of interest, of about 16 miles, to better categorize a modern quarantine zone.

II. Literature Review

Disasters show an impact on housing prices. The Loma Prieta earthquake, which effected San Francisco in 1997, showed that the price of a house is lower than what it previously was before. To measure the price of an individual house, a hedonistic price value is contrived. This means a house is measured based on its characteristics. A natural disaster can cause a reduction in market value of a house. This implies that the overall hedonistic price value of a house decreases. However, market failure only occurs if a homebuyer has an inaccurate view of a risk associated with buying a home *(Mueller & Loomis, 2007)* meaning a buyer did not know disasters can affect house price. The price level fell after the earthquake, indicating that consumers initially overestimate the earthquake hazard. Alistair Munro (2018) measures how radiation affected house prices in the city of Fukushima, after 2011. In this type of disaster, a 1% increase of radiation is followed by 0.051% drop in housing prices. After a year, however, radiation levels decreased and house prices became stable (Munro, 2018).

More relevant to our studies show how nuclear power plants affect residential value. A research done in University of Chicago investigates a similar idea, where the authors, Kirstin Munro and George Tolley, measured the correlation between property value around a closed power plant. When a power plant is decommissioned, nuclear waste, or spent nuclear fuel, stays in the facility for years. After collecting data on a range of residential and commercial properties near the power plant, they had come to the conclusion that a proximity to the closed power plant had no impact on property, and instead property tax increase was the reason for variation in property prices near the closed nuclear power plant (Munro & Tolley, 2018). Another study was conducted with the residential values of homes in close proximity towards an active and a non-active power plant. Clark (1995) took into consideration two sites, Diablo Canyon (active), and

Rancho Seco (non-active) in California, and measured hedonistic price level of homes relative to the distance from the power plants. The author came to the conclusion that even with high surveys of negative public opinions of the willingness to live, visit, or run a business near a nuclear facility, there is no evidence that the bad imagery translated into a significant detrimental impact on residential home prices. They concluded there was no correlation.

In contrast, in assessing nuclear risk, studies exist that show a negative effect on house prices. Olsen and Wolff (2013) measure housing and labor market effects around U.S. nuclear power plants from 1970 to 2000. Although power plants lower unemployment and increase education and skill level, a decrease in house value was found around a 10-mile radius of the plant (Olsen and Wolff, 2013). In evaluating other types of properties, such as agricultural land, nuclear power plant proximity had a significant negative externality on the property value (Folland and Hough, 1991).

We focus on how the exogenous event, the Fukushima crisis, effect housing prices in the U.S. We follow the work of one literature that focuses on the events of Fukushima and its correlations to behavioral economics. Tanaka and Zabel (2018) believe that large scale events tend to make people over react. More specifically, individuals overweight a local environmental risk. They measure this reaction by focusing their attention on house prices, after 2011, near nuclear power plants. They find a temporary decrease of house prices that dissipated a year after the crisis (Tanaka and Zabel, 2018). While this literature conducts a radius of 2 ½ miles, we set out to raise the radius to 16 miles. We also differentiate from this literature by setting to measure house prices before and after the Fukushima crisis.

III. Methodology

To understand the relationship between house prices and distance from a nuclear power plant, we use the "ordinary least square" (OLS) model. Another important distinction in our regression model is to use "log-level". This is to create a more appropriate and understandable estimation of measuring prices, with distance. We also account for year fix effects to all of our regressions. To start off, our dependent variable will be the log of sale prices of homes. Our regression starts off like this:

$$Ln(Houseprice)_i = \beta_0 + \beta_1 distance_{it} + \lambda_t + \varepsilon_i \tag{1}$$

Our main independent variable will be distance. We now add control variables. In this case, they are the total number of beds and baths, and also square footage of the property. We call our Bed/Bath variable A, and S variable for lot size. These are listed as:

$$Ln(Houseprice)_{it} = \beta_0 + \beta_1 distance_{it} + \beta_2 A_i + \beta_3 S_i + \lambda_t + \varepsilon_{it} \tag{2}$$

To explore the effect of distance to the plant after the Fukushima Daiichi incident, we introduce a dummy variable F. This variable takes on a value of 1 after the Fukushima accident, and 0 otherwise. We also take into consideration the distance interaction with our Fukushima dummy. To illustrate this, our third regression model turns out to be:

$$Ln(Houseprice)_{it} = \beta_0 + \beta_1 distance_{it} + \beta_2 A_i + \beta_3 S_i + \lambda_1 F_t + \lambda_2 F_t distance_i + \lambda_t + \varepsilon_{it} \tag{3}$$

We ran this regression in hopes to catch the direct effect of the Fukushima accident on house prices.

Next, we change our continuous variable distance, to a categorical value. We define D_1 for 4-8 miles, D_2 for 8-12 miles, and D_3 for 12-16 miles away from the nuclear power plant. This is introduced to keep a more precise variation with respect to houses located between 0 to 4 miles, which is dropped from the regression, away from the plant. Our fourth regression becomes:

$$Ln(Houseprice)_{it}=\beta_0 + \lambda_1 D1_i + \lambda_2 D2_i + \lambda_3 D3_i + \lambda_t + \varepsilon_{it} \tag{4}$$

Finally, we introduce our Fukushima dummy with distance being a categorical value. We do this so we capture variations of price within each increasing increment of distance. To do this, we bring back our Fukushima dummy, F, and also capture the interaction within each range of distance. This is shown in our last regression:

$$Ln(Houseprice)_{it}=\beta_0+\beta_1 A_i+\beta_2 S_i+\lambda_1 F_t+\lambda_2 D_{1i}+\lambda_3 D_{2i}+\lambda_4 D_{3i}+\lambda_5 D_{1i}F_t+\lambda_6 D_{2i}F_t+\lambda_6 D_{3i}F_t+\lambda_t+\varepsilon_{it} \tag{5}$$

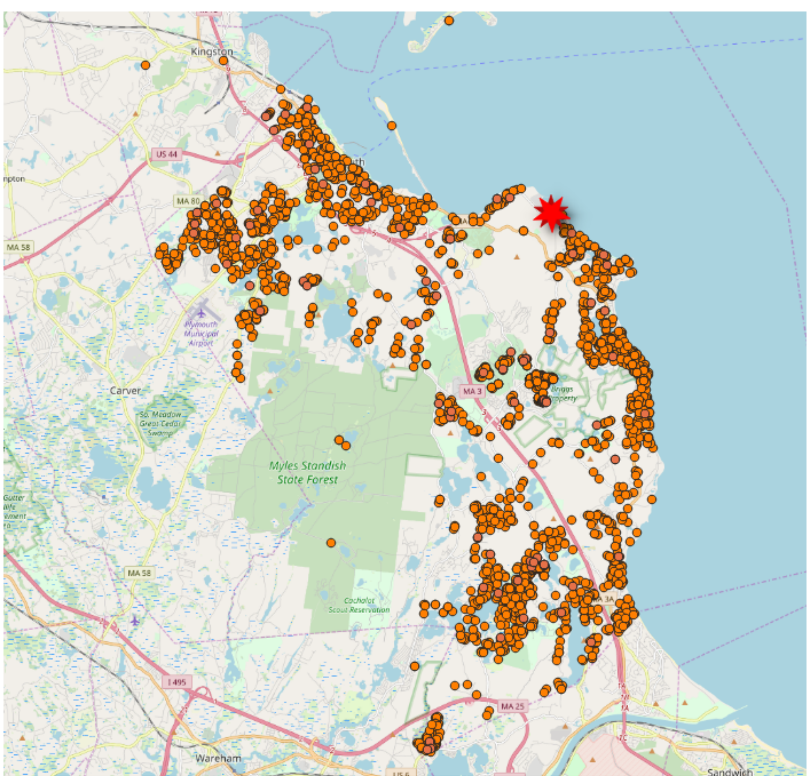
This full regression model will indicate how distance and the exogenous Fukushima incident will help determine and manipulate house prices.

IV. Data

Our analysis primarily focuses on house sale prices. We gather our data from the assessor's office in Plymouth, Massachusetts. The data that we focused on was a listing of single family homes that were sold through the years of 2004 -2017. We focus on this period because it covers 7 years before and 4 years after the Fukushima accident.

From the database provided by the assessor's office of Plymouth, Massachusetts, we retrieved the data for our variables to build a regression model. By already having a listing of prices of sold single-family homes, we were able to easily list the sale prices of homes in the given town. The address of homes sold were also retrieved. Total number of beds and bathroom, and square footage of homes were gathered in order to control for these variables in our regression model. Lastly, sales date of each individual house was gathered.

Distance is our main explanatory variable, but we introduced categorical increments of distance to measure a precise variation of price within each range of miles. Finding distance from an individual house to the nuclear power plant was not so readily available. We resorted to a process called geocoding, which gives us a precise location, in latitude and longitude, of an individual location, in this case a house. We were able to successfully locate our addresses listed for sale, and we turned to QGIS, which is a geographic information system software, to visually see and locate our houses and the plant. We then followed to filter out locations that were not geocoded properly, thus making sure our locations were precise and left little room for uncertainty.



The diagram above shows a visual example of locations on single family homes that were listed for sale between the years of 2004-2009. We don't include locations from 2010-2017 so the diagram doesn't become oversaturated. The orange dots represent houses that were sold, and the larger red dot represents the nuclear power plant site. From the diagram, we also get a better understanding of where the residential areas of Plymouth are located.

We follow up by creating a distance matrix, in other words, create a table listing the distance from every individual house to the power plant, measured in miles. We set the distance to a max of 20 miles, so the houses were located inside our targeted town. We also create 4 new tables that groups homes from distance of 0-4 miles, 4-8 miles, 8-12 miles, and 12-16 miles away from the plant.

We now create a column, called Fukushima, equal to 0, if the sale date was before 2011, and 1 otherwise. Furthermore, an additional 4 new columns are introduced that records the interaction between the Fukushima column, and the incremental distance columns.

Table 1a: Descriptive Statistics

	Lot size	**Bed/Bath**	**Price**	**distance**	**Fukushima**	**Year**
count	6536	6536	6536	6536	6536	6536
mean	27835.697215	4.763617	3.575104e+05	5.930195	0.634333	12.015912
std	34643.130482	1.270571	2.217389e+05	2.850145	0.481654	4.276631
min	0.000000	0.000000	1.000000e+00	0.342914	0.000000	4.000000
25%	9583.000000	4.000000	2.528750e+05	3.935707	0.000000	8.000000
50%	19998.000000	5.000000	3.250000e+05	5.595161	1.000000	13.000000
75%	30453.000000	6.000000	4.198100e+05	8.028218	1.000000	16.000000
max	645956.000000	14.000000	4.500000e+06	19.966043	1.000000	17.000000

Table 1b: Descriptive Statistics

	d_0_4	d_4_8	d_8_12	d_12_16	Fdis0	Fdis1	Fdis2	Fdis3
count	6536	6536	6536	6536	6536	6536	6536	6536
mean	0.258262	0.488066	0.218635	0.031518	0.170441	0.300490	0.142289	0.019278
std	0.437712	0.499896	0.413352	0.174726	0.376048	0.458506	0.349373	0.137510
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
50%	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
75%	1.000000	1.000000	0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
max	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

Our main explanatory variable, distance, show an average distance to be 6 miles from the nuclear power plant. We also notice that the average price of a house sold was about $357,510. Price and distance both have a standard deviation below the mean, which indicated a little bit of a skewed data. Our table shows the listing for the years between 2004-2017. The year that the most amount of homes were sold was 2012, which is after the Fukushima accident. The average size of a house is 34,643 square feet. The average number of beds and baths is 5.

V. Results

Table 2 and table 3 show the regression results. According to our 5 regressions, we overall conclude that distance from the nuclear power plant had a negative relationship with prices of homes. Housing prices declined the further they were to the nuclear power plant.

Our first regression was with distance alone, with price level of a single-family house and year fix effects. As shown, for every one increment of distance, (every additional mile), the price of a house decreases by 2.4% in value. Our adjusted R^2 is 0.043, which is low, but may change as we add more variables to our regression.

In our second regression, we include total number of beds and baths, and lot size. Our results show that the distance coefficient only increases by .1%. We also notice that as you increase one value of total number of beds and baths, the price of the house is going to increase by 16.7%. The Bed/Bath variable also seems to impact prices more than our explanatory variable, distance. Another thing to note is that all our variables are significantly significant. Lastly we notice our new adjusted R^2, which raised to 0.228. This means that 22% of the variation of prices is explained by our independent variables.

For our third regression, we add our exogenous event dummy variable, Fukushima, and see if there was any change in the relationship between price and distance before and after the Fukushima disaster. The Fukushima coefficient is positive, meaning that after the Fukushima event in 2011, prices increased on average, by 9.5%. We now look at the interaction of distance and the Fukushima dummy. We see that the coefficient is negative, 1.0%. This implies that after the Fukushima accident, house prices decreased by 2.6% with increasing distance. We come to this conclusion by combining our distance variable with the interaction with distance variable. Lastly all our variable showed to be statistically significant.

Table 3 changes the continuous distance variable into a categorical variable. We notice in the first regression that all the coefficient in our variables for distance, 4-8, 8-12, 12-16, are negative and statistically significant. We also notice house price value decreases more, as distance increases. In the second regression, the interaction of the Fukushima dummy and the categorical values are minimal and insignificant, all but the last interaction between houses at the 12-16 mark.

To measure for a difference in difference relationship, we compare our results to a similar seacoast area north of Massachusetts, in Salisbury, to see if prices fluctuates because of the plant or because of location. Table 4 shows the results of this comparison. Distance and house prices are still correlated negatively. We find that, in addition to the house prices in the Salisbury area, the house prices in Plymouth decrease after 2011, by 1.4%, and insignificant. We also see that the distance interaction with the Fukushima dummy in Plymouth is mute and insignificant as well.

VI. Conclusion

In this paper, we set out to find how the Fukushima crisis effected house prices in Plymouth, Massachusetts. This study challenges the perception on how natural disasters effect property value. We add to previous literature by measuring the interaction of the actual event of Fukushima, with increase of distance from a specific power plant. We find no decrease in house prices given the exogenous event, the Fukushima crisis. Additionally, we see no direct decrease in house prices with the interaction between distance and the Fukushima crisis, close to the plant.

Our empirical analysis is conducted in way that we focus on one specific region, Plymouth, Massachusetts. A complication of the study can be found that the Fukushima crisis may have effected other residential homes located near a nuclear power plant across the U.S. with more correlation. Another obstacle in this study is the seasonal effects the town may experience due to its historical location. Consequently, it cannot be completely concluded that the interaction between distance from a plant and the exogenous event of Fukushima had a weak correlation with house prices.

APPENDIX

CHART 1:

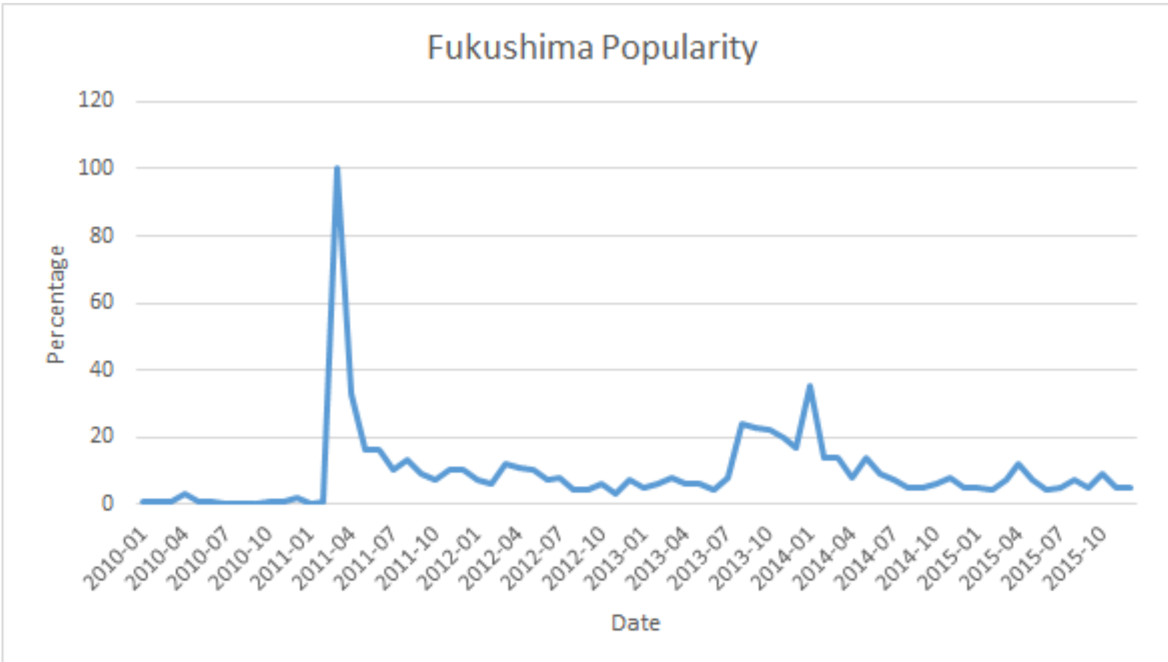


TABLE 2:

Regressions Part 1

	Dependent variable:		
	Price		
	(1)	(2)	(3)
distance	-0.024***	-0.023***	-0.016***
	(0.002)	(0.002)	(0.003)
Bed/Bath		0.167***	0.167***
		(0.005)	(0.005)
Lot size		0.00000***	0.00000***
		(0.00000)	(0.00000)
Fukushima			0.146**
			(0.058)
Fukushima and distance			-0.010**
			(0.004)
Constant	12.849***	12.007***	11.967***
	(0.029)	(0.034)	(0.038)
Year FE	Yes	Yes	Yes
Observations	6,536	6,536	6,536
R^2	0.045	0.230	0.231
Adjusted R^2	0.043	0.228	0.229
Residual Std. Error	0.513 (df = 6521)	0.461 (df = 6519)	0.461 (df = 6517)
F Statistic	21.965*** (df = 14; 6521)	121.879*** (df = 16; 6519)	108.947*** (df = 18; 6517)
Note:			*p **p ***p<0.01

TABLE 3:

Regressions Part 2

	Dependent variable:	
	Price	
	(1)	(2)
Bed/Bath	0.165***	0.165***
	(0.005)	(0.005)
Lot size	0.00000***	0.00000***
	(0.00000)	(0.00000)
Fukushima		0.090
		(0.056)
4-8 miles	-0.046***	-0.045*
	(0.014)	(0.023)
8-12 miles	-0.104***	-0.093***
	(0.017)	(0.028)
12-16 miles	-0.342***	-0.261***
	(0.034)	(0.055)
Fukushima with 4-8 miles		-0.001
		(0.029)
Fukushima with 8-12 miles		-0.016
		(0.035)
Fukushima with 12-16 miles		-0.132*
		(0.070)
Constant	11.938***	11.932***
	(0.033)	(0.035)
Year FE	Yes	Yes
Observations	6,536	6,536
R^2	0.229	0.230
Adjusted R^2	0.227	0.228
Residual Std. Error	0.461 (df = 6517)	0.461 (df = 6513)
F Statistic	107.836*** (df = 18; 6517)	88.556*** (df = 22; 6513)

TABLE 4:

Regressions Part 3

	Dependent variable:				
	Price				
	(1)	(2)	(3)	(4)	(5)
distance	-0.015***	-0.014***	-0.008***		
	(0.001)	(0.001)	(0.002)		
distance and Plymouth	-0.010***	-0.014***	-0.012***		
	(0.001)	(0.001)	(0.002)		
Lot Size		0.00000***	0.00000***	0.00000***	0.00000***
		(0.00000)	(0.00000)	(0.00000)	(0.00000)
Lot Size in Plymouth		0.00000***	0.00000***	0.00000***	0.00000***
		(0.00000)	(0.00000)	(0.00000)	(0.00000)
Fukushima			0.051		-0.004
			(0.052)		(0.049)
Fukushima and Plymouth			-0.014		-0.002
			(0.028)		(0.023)
Fukushima and distance			-0.010***		
			(0.002)		
Fukushima, distance and Plymouth			-0.002		
			(0.004)		
4-8 miles				0.083***	0.085***
				(0.020)	(0.031)
4-8 miles in Plymouth				-0.148***	-0.130***
				(0.021)	(0.031)
8-12 miles				0.143***	0.180***
				(0.021)	(0.035)
8-12 miles in Plymouth				-0.275***	-0.269***

				(0.024)	(0.039)
12-16 miles				-0.183***	-0.115***
				(0.013)	(0.022)
12-16 miles in Plymouth				-0.288***	-0.283***
				(0.036)	(0.057)
Fukushima with 4-8 miles					0.007
					(0.042)
Fukushima with 4-8 miles in Ply					-0.035
					(0.046)
Fukushima with 8-12 miles					-0.057
					(0.044)
Fukushima with 8-12 miles in Ply					-0.010
					(0.052)
Fukushima with 12-16 miles					-0.106***
					(0.030)
Fukushima with 12-16 miles in Ply					-0.011
					(0.077)
Constant	12.876***	12.811***	12.752***	12.724***	12.695***
	(0.021)	(0.021)	(0.024)	(0.019)	(0.022)
Observations	12,277	12,277	12,277	12,277	12,277
R^2	0.053	0.086	0.088	0.107	0.108
Adjusted R^2	0.052	0.085	0.086	0.105	0.106
Residual Std. Error	0.508 (df = 12261)	0.499 (df = 12259)	0.498 (df = 12255)	0.493 (df = 12255)	0.493 (df = 12247)
F Statistic	45.654*** (df = 15; 12261)	67.776*** (df = 17; 12259)	56.023*** (df = 21; 12255)	69.600*** (df = 21; 12255)	51.181*** (df = 29; 12247)
Note:					*p**p***p<0.01

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