Impact of a Disaster on Land Price: Evidence from Fukushima Nuclear Power Plant Accident

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Abstract

The Great East Japan Earthquake, which occurred on March 11, 2011, triggered the Fukushima nuclear power plant accident. This study estimates the economic damage caused by the radioactive contamination from the plant using a hedonic approach. Our estimation results show that an increase of 1 $\mu Sv/h$ decreases the land price by 3.39% on average in Fukushima and Miyagi prefectures. Specifically, damage due to the radiation effect is estimated to cost approximately 64.1 billion yen in Fukushima. In addition, our result shows that commercial and business areas are more sensitive than residential areas to the radiation quantity.

Keywords: Disaster; Hedonic model; Nuclear power plant accident; Land use type.

1 Introduction

The number of large-scale disasters has been increasing over the years all over the world. It is now more important than ever to adapt to disasters. For example, the losses from recent natural disasters are more than eight times greater than the losses suffered as a result of natural disasters during the 1960s (EM-DAT, 2009). The Great East Japan Earthquake that occurred on March 11, 2011, is the one of the world's largest disasters in terms of economic losses. Such large-scale disasters cause both short-term and long-term economic losses. In the case of the Great East Japan Earthquake, the industrial production index dramatically decreased in the damaged area, and the non-damaged areas suffered from the shortage of materials. Thus, the number of final products decreased (Okada et al., 2011).

Tanikawa et al. (2014) concludes that the material stock losses of buildings and road infrastructure are 31.8 and 2.1 million tons, respectively. A large portion of infrastructures were damaged by earthquakes and tsunamis. These results show earthquakes affect both short- and long-term economic conditions in Japan. In addition, recent studies note that large-scale disasters have the potential to change the preference of victims (for example, Cameron and Shah, 2013). As the number of disasters increases over time, implications of results from disasters studies become more important to compare to others, which provides the relative effects from the disasters. Japan experienced multiple disasters in which an earthquake and/or tsunami consequently triggered another disaster. In the case of the Great East Japan Earthquake, an earthquake and consequent tsunami caused the nuclear power plant disaster of Fukushima. This nuclear power plant accident made changes in nuclear power policy at least short term in Japan, and also other countries such as Germany. This event might be the most influential accident to the world as Japan' nuclear power plant was considered to be sage from engineering firms and policy maker' viewpoints.

The Fukushima nuclear power plant accident caused widespread pollution of the land byradioactive contamination. Nuclear power plant accidents complicate the policy-making process for reconstruction after the earthquake. Therefore, we need to better understand how much each factor affects economic damage. Several studies have analyzed nuclear power plant accidents of different countries (Nelson, 1981; Yamane et al., 2013); these studies apply a hedonic approach to estimate the economic losses caused by nuclear power plant accidents.

In this paper, we also analyze the economic damage of the nuclear power plant accident using the hedonic approach based on publicly disclosed land price data. We estimate the effect of the nuclear power plant accident by controlling for the direct damage of the earthquake. Our results highlight the relationship between the radiation quantity and the decreasing land price in Fukushima and Miyagi prefectures where these two are expected to have largest effects from disaster. Additionally, the radiation effects differ according to the land use pattern.

2 Background

The hedonic pricing method is widely used for estimating the externality of the environment (see Hibiki and Managi, 2011). Since Ridker and Henning (1967) estimated an externality of environmental quality using residential property values, many researchers have used the hedonic approach to measure the benefits and costs of environmental quality. In recent years, many applications have been described in environmental economics literature (Kim et al., 2003; Bayer et al., 2009; Kim and Goldsmith, 2009). For example, Gopalakrishnan et al. (2011) measure the value of beaches in Coastal North Carolina, US, using the hedonic approach. They estimate the implicit price of beach widths using instrumental variables.

Researchers have also attempted to estimate the effect of disasters using residential property price and land price data. Bin and Polasky (2004) estimate the effect of flood risk on residential property prices and find that a house located within a floodplain has a lower market value than an equivalent house located outside a floodplain. Hallstorm and Smith (2005) also estimate the effect of flood risk on land price. Beron et al. (1997) compare residential prices in the San Francisco bay area before and after the Loma Prieta earthquake. They find that the hedonic price fell after the earthquake; thus, residents had initially overestimated the earthquake hazards. In Japan, Nakagawa et al. (2009) analyzes how land prices reflect earthquake risks from 1980 to 2001 using a hazard map complied for the entire region by the Tokyo metropolitan government, Japan, in 1998. They reveal that earthquake risks are reflected in land prices. Their estimation results show that the land price of the riskiest areas is 8% lower than that of the safest areas. As discussed previously, several studies focus on the effects of disasters on land prices. While some studies focus on effects of nuclear power plant disasters on land and residential property prices (for example, Gamble and Downing, 1982), few studies have measured this effect. One of the few examples is Nelson (1981) who analyzed the effect of the Three Mile nuclear power plant accident on property values.

In this paper, we estimate the effect of the nuclear power plant accident caused by the Great East Japan Earthquake that occurred on March 11, 2011. The Great East Japan Earthquake not only caused direct casualties but also caused radiation damage via the nuclear power plant accident of the Fukushima Daiichi nuclear power plant. The accident potentially decreased the land value of Fukushima prefecture and the nearby region. We attempt to capture the effect of the nuclear power plant accident using observations of radiation quantity data. After the earthquake, the Ministry of Education, Culture, Sports, Science and Technology in Japan published observation data of radiation amounts on their website. Thus, residents and business people may consider such information when purchasing land.

Yamane et al. (2013) also estimate the effect of the nuclear power plant accident in Fukushima. They use the distance from the Fukushima Daiichi nuclear power plant and dummy variables classified by the radiation quantity to capture the effects of the nuclear power plant accident. They use the property values of the neighboring region of the Fukushima Daiichi nuclear power plant for their sample.

In contrast, we use the data of the "*Official land price*", which is *Kouji chika* in Japanese. These data include several types of land, such as industrial and agricultural land. Our results, which reveal the differences of the radiation effect according to each land pattern, are unique among the literature. Conventional residential owners may have higher or lower prices attached to radiated land compared to the business, commercial and agricultural sectors. Residents may be more cautious of radiation because it affects the place they live, or business people may care more due to the negative image associated with radiation.

3 Models and Data

3.1 Data

We use the land price data and information of the characteristics of each land type for 2011 and 2012. A sample consists of the land area data from Fukushima and Miyagi prefectures (see Figure 1). Note that Miyagi prefecture is next to Fukushima prefecture and was closer to the epicenter of the earthquake than Fukushima or any other prefectures. The sample size is 942 (of observations of Fukushima: 416 samples; Miyagi: 526 samples). The land price data was obtained from the "*Official land price*" published by the Ministry of Land, Infrastructure, Transport and Tourism, Japan in 2011 and 2012. In addition, some characteristics of the land are described in the official land data. Based on information of the "*Official land price*", we construct dummy variables of the land types using classifications (residential area, retail premises, office area, factory area, agricultural area, or vacant space) and the distance from each area to a station.

The radiation quantity data was obtained from the "*Distribution map of radiation quality and others*" (Ministry of Education, Culture, Sports, Science and Technology, 2011, 2012). We apply the radiation quantity data of each monitoring point that is nearest the point of each land area. The population densities are calculated by population and area size data at the municipal level (Bureau of Statistics in Fukushima Prefecture, 2011 and 2012; Bureau of Statistics in Fukushima Prefecture, 2011 and 2012). The number of fatalities and injured persons by the earthquake in each municipality is obtained from the report of Disaster Countermeasures Office of Fire and Disaster Management Agency (2013). Table 1 shows descriptive statistics of each variable. This database is part of World Resource Table (WRT) (see Miyama and Managi (2014) and Yang et al. (2014) for detail). WRT intends to cover database for easy access different database on economy, resource, and environment (Kagawa et al., 2014).

3.2 Model

We use the hedonic approach to estimate the effect of the nuclear power plant accident. The hedonic approach is a common measurement method for estimating the externality of the environment once information is known to the public. In this case study, the radiation effects are clearly known to the public because the large-scale, negative event commonly appeared in the media, such as newspapers. In this model, we use the percentage change of the land price between 2011 and 2012 as a dependent variable. Our model includes several independent variables to capture several characteristics of each land type. We formulate the following equation:

Model 1:

$$\begin{aligned} Land_i = \beta_1 Radiation_i + \beta_2 Popden_i + \beta_3 Station_i + \beta_4 Land\ Dum_i + \beta_5 Gas_i \\ + \beta_6 Fatalities_i + \beta_7 Station\text{-}b_i + \beta_8 Rail_i + c + \varepsilon_i \qquad (1) \end{aligned}$$

where *i* indicates each place of land based on the "*Official land price*" data from the Ministry of Land, Infrastructure, Transport and Tourism in Japan for 2011 and 2012[1]. The dependent variable is the percentage change of the land price. "*Radiation*" is a variable that captures the radiation effect on the land price. We use the radiation quantity ($\mu Sv / h$) [2]and a dummy variable that determines whether the radiation quantity exceeds 1 $\mu Sv / h$ (see Ministry of Education, Culture, Sports, Science and Technology, 2011[3]). The International Commission on Radiological Protection (ICRP) establishes a base line of whether the radiation quantity exceeds 1 $\mu Sv / h$. A discussion of the ICRP appeared in the newspapers of Japan. Thus, people may use such baseline information as a reference for land transactions. "*Popden*" refers to the change of the population density (head count per km), which is the population per area. If a large change of the population occurs, then the demands of the land use patterns may change. To capture the differences of the land characteristics, we add "*Station*", "*Land Dum*" and "*Gas*" to the model. "*Station*" is the change of distance from each land place to a nearest station (m). Distance from each land place to a nearest station is also described in "Official land price". In local area, some

[1] We use the percentage change of the land price between 2011 and 2012 as a dependent variable. However, some places disappeared from the data by the second year; thus, we exclude such data from the observations.

[2] $\mu Sv / h$ implies micro sievert per hour. Sivert is the index of radiation effect for organism (include human).

[3] Radiation quantity data are observational data between June 6, 2011 and July 8, 2011.

stations are closed down due to the shutdown of train line. Previous studies show that farther distances from a station decrease the land price. If the nearest station closes down, land value affected by change of distance from station. To control such an effect, we include the change of distance from a place to a station between 2011 and 2012. "*Land Dum*" are dummy variables based on land usage. We classify each dummy according to the type of land: residential area, retail premises, office area, factory area, agricultural area, vacant space[4]. "*Gas*" is a dummy variable that determines whether urban gasoline can be used. These variables about characteristic of each land obtain from information of "*Official land price*". In addition, we add other variables to control the effects of earthquake damage. "*Fatalities*" is the percentage of fatalities caused by the earthquake per population of each municipality. "*Station-b*"[5] refers to the dummy variable of whether the local station in each place was damaged by the earthquake. "*Rail*" is the dummy variable of whether the local train line was damaged by the earthquake. "c" is a constant term. "ε" is a disturbance term.

We can measure the radiation effect for land value from estimation results of model 1. However we need to better understand about the effect of radiation for policy making. For

[4] In this model, we exclude the dummy variable of the residence area.

[5] Data of "*Station-b*" and "*Rail*" are obtained from several open data sources. We get the data of these variables from homepage of each city office, each train company and other open access information sites.

example radiation effects on land prices may vary by land use pattern. If residents fear the radiation impact of ill health, they tend to move out of polluted areas over short periods. Land price of such area dramatically decline compared with other area. If such effects occur, policy maker need to consider such effect for policy making. Specifically, policy maker need to consider priority area of the decontamination for mitigation of economic damage. To check for the existence of such a phenomenon, we estimate another model using the following equation:

Model 2:

$$\begin{aligned} Land_i &= \beta_9 Radiation_i \times Land\ Dum_i + \beta_{10} Popden_i + \beta_{11} station_i + \beta_{12} Gas_i \\ &+ \beta_{13} Fatalities_i + \beta_{14} Station\text{-}b_i + \beta_{15} Rail_i + c + \varepsilon_i \qquad (2) \end{aligned}$$

The cross term of the radiation quantity and land using a dummy ("*Radiation*×*Land Dum*") captures the radiation effect by each land use type. In model 1, we exclude the dummy variable of residential area from the model. On the other hand, we use all dummy variables of the land use types in model 2 to show the differences of the radiation effects on each land use. Our data do not include the outlier from classification of land dummy. Thus cross term of the radiation quantity and dummy variables of the land use types can directly compare how much differences of radiation effect occur on each land using. Considering multicollinearity with the radiation quantity and dummy variables, we exclude the “Radiation” is not cross term.

4 Estimation results: Land price and economic damage due to radiation

4.1 Econometric result of land price

Table 2 shows the estimation results of model 1. The variables of “Radiation” (i.e., radiation quantity and dummy variable of whether a radiation quantity exists) have negative coefficients in both of the specifications. Our estimation results show that differences in the land use patterns affect the land price. We find that a reduction of the land price in commercial areas and businesses areas larger than the reduction of the land price in residential areas. These results imply commercial and business areas are more sensitive to disasters than residential areas.

We also find that variables capturing the effect of the earthquake damage have a negative relationship with the land price. The number of fatalities and injured persons has a negative relationship with the land price. In addition, rail traffic hindrance (“Rail”) has a negative coefficient in both of the specifications.

Table 3 shows the estimation results of model 2. The cross term of radiation quantity and the land use pattern dummy has a negative coefficient in all instances. In particular, the business area variable exhibits the greatest negative rate of land price. The cross terms of residential area, factory area and agricultural area also exhibit a negative relationship with the land price. The cross term of blank space does not exhibit a statistically significant relationship. Comparing the coefficients of all of the cross terms, the cross term of residential area and radiation quantity yields the weakest negative coefficient. These results intend to show that residents of polluted areas have difficulty moving to other relatively safe areas compared with business and commercial sectors. This finding provides several possibility of implications. One possibility is sensitivity for pollution. People living in polluted areas are not sensitive to the damage from radiation. Second possibility is increasing of demand by labor for rehabilitation. In fact, Results of Gamble and Dowing (1982) imply undermine the radiation effect by residential demand of cleanup workers. Third possibility is specific effect of residential behavior. This finding might reflect the fact residents have an attachment to the original location they lived (see Horie and Managi, 2014). If such effect occurs, demands of residential area do not tend to decrease.

4.2 Damage calculation of the nuclear power plant accident

Based on our estimations, we now calculate how much the land price decreased due to the radiation quantity in each municipality. Calculating formula of damage as follow:

$$Damage_j = \beta_9 \times radiation_j \times land_j \times Area_j \qquad (3)$$

j show the each city , town and village in Fukushima and Miyagi. "*radiation*" is the average radiation amount of each city, town and village. "land" show the average land price in each city, town and village. "*area*" is the square measure of each city, town and village[6]. β_9 is the parameter that are estimated by formulation (1).

Our calculations are shown in table 4 (for Fukushima prefecture) and table 5 (for Miyagi prefecture). We note the main damaged area by radiation is Fukushima prefecture. However, the southern Miyagi prefecture also suffers from radiation damage due to its closeness to Fukushima and the direction of the wind at the time (i.e., the wind was directed from south (Fukushima prefecture) to north (Miyagi prefecture) region).

Our calculations show that the damage in Miyagi prefecture is lower than the damage in Fukushima. Clearly, the distance to the accident (i.e., Fukushima Daiichi nuclear plant) and the radiation quantity are strongly correlated. The land price near the nuclear power plant is more inexpensive than other areas before the accident. Although its radiation level is higher than other areas, the economic damage might be lower than that in other areas.

Figure 2 shows the damage of each area on a map of Fukushima prefecture. The economic center of Fukushima (i.e., near Fukushima-city and Koriyama-sity) shows a high economic loss

[6] We obtain the data of square measure in each city, town and village from Geospatial Information Authority of Japan (2011).

due to the decrease of the land price caused by the radiation. Obviously, other areas also show a high level of radiation. However, the land prices of other areas are less expensive. Therefore, other areas show lower economic losses compared with areas that are near the economic center of Fukushima.

Figure 3 shows the damage to each area on a map of Miyagi. The damage in Miyagi prefecture is lower than the damage in Fukushima prefecture. However, there are several municipalities that show higher damage due to radiation. For example, the damage in Aoba-ku exceeds 500 Yen per m^2. The land price of Miyagi prefecture is higher than the land price of Fukushima prefecture. These findings show that the economic effect of radiation in several areas in Miyagi prefecture is high even though the radiation quantity is low.

Previous studies show the negative effect of nuclear power plant accident for properties value has limited (Gamble and Dowing, 1982; Nelson, 1981). They use the distance from nuclear plant as variables to capture the negative effect of nuclear power plant accident. But Gamble and Dowing (1982) mention the difficulty about the estimation of such effect by the distance of nuclear plant. In reality, there was no evidence suggesting changes in the value of proximity to the plant in Yamane e et al. (2013). Yamane et al. (2013) find the correlation between the property value and dummy variables classified by contamination level[7]. They show the prices of areas that are contamination level between 0.5 to 1.0 are 3.2% lower than price of baseline area. On the other hand, we also show that the radiation levels affect the land prices. An increase of 1 $\mu Sv/h$ decreases the land price by 3.39%. We cannot compare with results of previous studies directly. However radiation effect that we estimate is smaller than results of Yamane et al. (2013). They use the value of residence as dependent variable. But we use the land value as dependent variable. Generally, values of residences are more sensitive for some event than land value. Therefore our estimation results are smaller than them results.

5 Discussion and conclusion

There is a growing literature on economics of disaster. Tohoku Great Earthquake on March 11, 2001 and its consequence to nuclear power plant problem in Fukushima, Japan provides unique opportunity to understand the economic mechanism after the disaster. This study estimates the economic damage of the Fukushima nuclear power plant accident using a hedonic approach. Our main findings are as follows. First, we show that the radiation levels

[7] Yamane et al. (2013) classify the each contamination level into 5 level based on radiation amount. Radiation amount of base line level is from 0.0 to 0.1 $\mu Sv/h$.

affect the land prices. An increase of 1 $\mu Sv / h$ decreases the land price by 3.39%. The economic damage to land prices caused by the radiation effect is estimated to be approximately 64.1 billion yen in Fukushima where Fukushima is the region affected by nuclear power accident. The radiation effect on land prices is also estimated in Miyagi prefecture where Miyagi is the region affected by earthquake and tsunami. The economic damage in Miyagi prefecture caused by the nuclear power plant accident is less than the damage in Fukushima prefecture. However, we need to consider such regional damage events other than Fukushima for future policy making concerning nuclear power plant accidents and its management.

Second, our results reveal that radiation effects differ by land use types. Our result shows that commercial and business areas are more sensitive to the radiation quantity than the residential areas. This finding implies that people who live in residential areas of Fukushima and Miyagi prefectures might face difficulty in moving to other areas. Of course, our estimation results can not reveal what the factor is to decrease the sensitivity of residents. However, policy maker need to have more attention such phenomenon to promote the policy for reconstruction of the regions.

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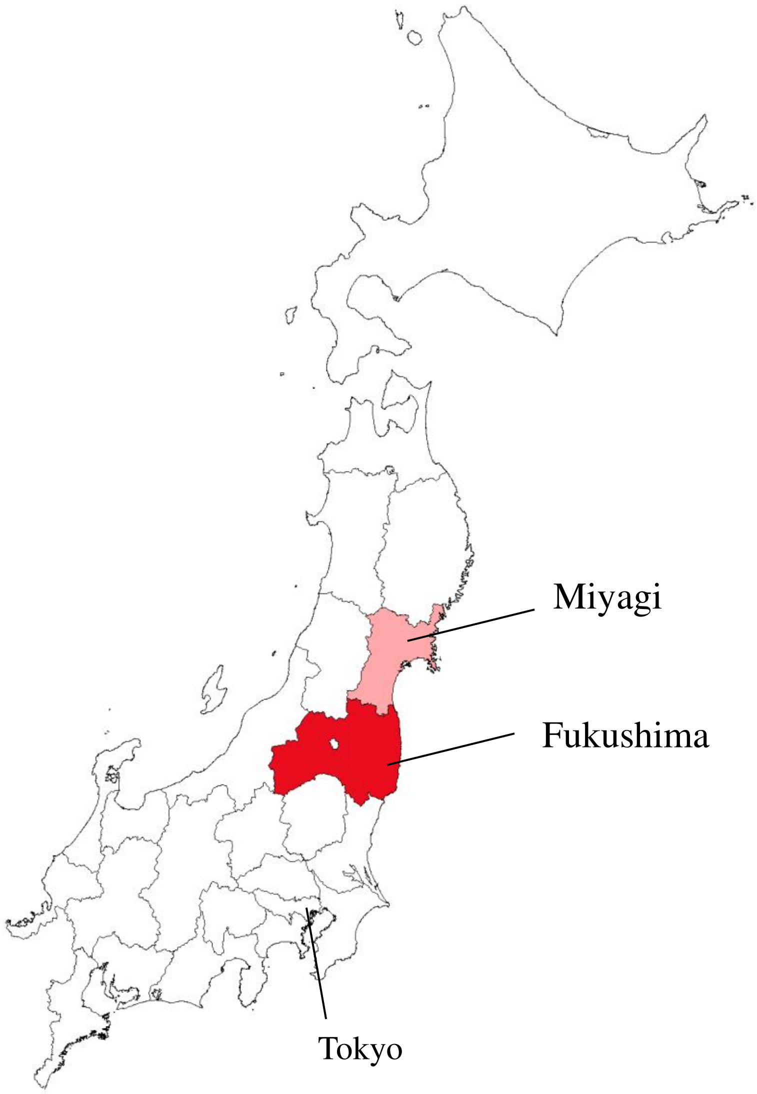
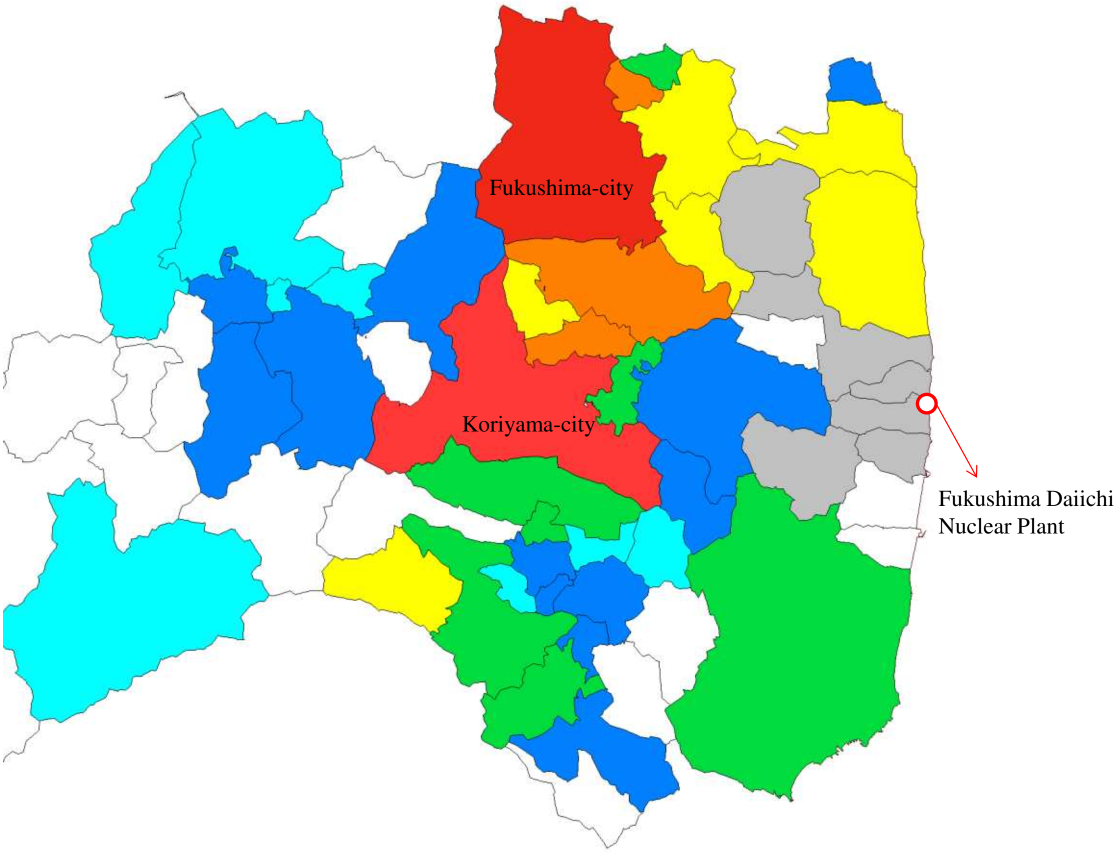


Figure 1 Map of east Japan

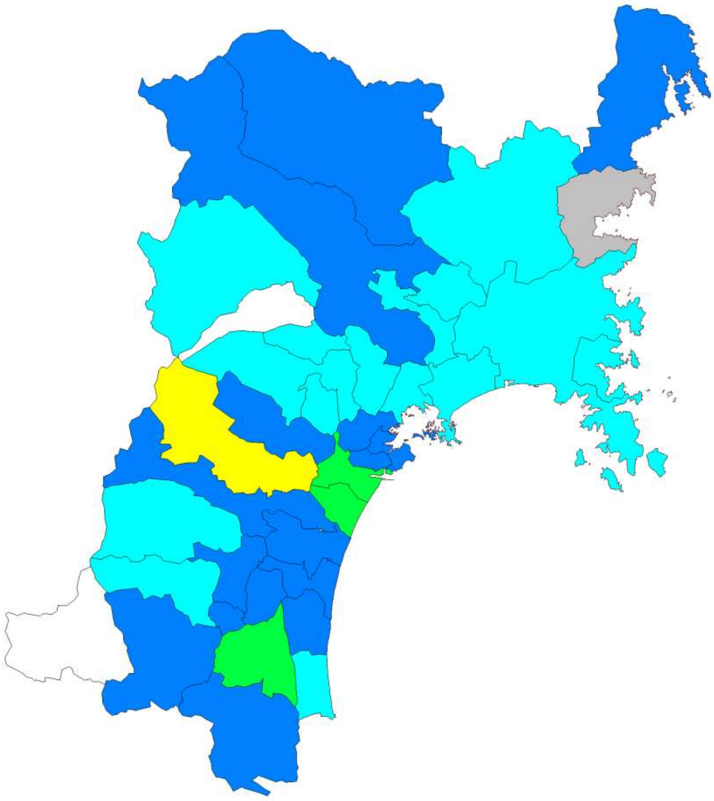


■ Over 2,000Yen, ■ 1,000Yen to 1999Yen, ■ 500Yen to 999Yen,

■ 300Yen to 499Yen, ■ 100Yen to 299Yen, ■ Under 100 Yen,

■ Off-limits area or broken-down area by tsunami, □ Data not available

Figure 2 Loss from radiation effect on land price in Fukushima prefecture (Japanese Yen per m^2)



■ Over 2,000Yen, ■ 1,000Yen to 1999Yen, ■ 500Yen to 999Yen,

■ 300Yen to 499Yen, ■ 100Yen to 299Yen, ■ Under 100 Yen,

■ Off-limits area or broken-down area by tsunami, □ Data not available

Figure 3 Loss from radiation effect on land price in Miyagi prefecture (Japanese Yen per m^2)

Table 1 Descriptive statistics

Variable	Average	Standard deviation	Min	Max	Remarks column
Land(Yen per m^2)	-0.038	0.044	-0.270	0.607	
Popden (head count per km^2)	-4.679	30.129	-110.250	46.940	
Station (m)	86.805	861.284	-2700.000	12800.000	
Gas	0.512	0.500	0	1	1:Available
Fatalities	2.678	25.742	0	280.558	
Station-b	0.028	0.164	0	1	1: Broken
Rail	0.157	0.364	0	1	1: Damaged line
Radiation					
Radiation amount	0.372	0.492	0.070	3.000	
Base line	0.118	0.323	0	1	1: Exceeding of base line
Land Dum					
Residential	0.724	0.447	0	1	
Commercial	0.210	0.408	0	1	
Business	0.046	0.209	0	1	
Factory	0.011	0.103	0	1	
Farming	0.006	0.080	0	1	
Vacant space	0.003	0.056	0	1	

Note) "*Land*"(Land price) is the percentage change of the value between 2011 and 2012.
"*popden*"(Population density) and "*Station*"(Distance from station) is the change of each value between 2011 and 2012.

Table 2 Estimation result of Model 1

	Radiation quantity	Base line
Radiation	-0.0339*** (-13.14)	-0.0366*** (-8.93)
Popden	-0.0000 (-0.62)	-0.0000 (-0.22)
Station	0.0000 (1.20)	0.0000* (1.68)
Commercial land	-0.0208*** (-6.72)	-0.0232*** (-7.21)
Business	-0.0215*** (-3.57)	-0.0205*** (-3.26)
Factory	-0.0177 (-1.45)	-0.017 (-1.36)
Farmland	-0.0016 (-0.10)	-0.0086 (-0.52)
Vacant	0.0059 (0.26)	0.0091 (0.39)
Gas	0.0127*** (5.03)	0.0145*** (5.51)
Fatalities	0.0001* (1.74)	0.0001** (2.10)
Station broken	0.0102 (1.09)	0.0042 (0.43)
Rail	-0.0121*** (-3.18)	-0.0123*** (-3.07)
c	-0.0252*** (-10.74)	-0.0339*** (-14.93)
R2	0.2362	0.1658

Values in parentheses are t-values. *Significant at the 10% level, **Significant at the 5% level, ***Significant at the 1% level.

Table 3 Estimation result of Model 2

	Radiation quantity
Residence	-0.0307*** (-10.01)
Commercial land	-0.0429*** (-10.38)
Business	-0.0563*** (-3.87)
Factory	-0.0382** (-2.09)
Farmland	-0.0329** (-2.09)
Vacant	0.0375 (0.19)
Popden	-0.0000* (-0.76)
Station	0.0000 (1.29)
Gas	0.0134*** (5.16)
Fatalities	0.0001* (1.86)
Station broken	0.0106 (1.09)
Rail	-0.0123*** (-3.16)
c	-0.0309*** (-13.53)
R2	0.1995

Values in parentheses are t-values. *Significant at the 10% level, **Significant at the 5% level, ***Significant at the 1% level.

Table 4 Radiation effect for land price in each municipals of Fukushima

Municipal	Average land price (Yen per ㎡)	Average radiation amount(μSv per hour)	Radiation effect (Yen per ㎡)
Souma-city	37,940	0.47	-604.619
Minami Souma-city	28,029	0.83	-788.81
Date-city	25,210	1.04	-888.982
Fukushima-city	48,894	1.29	-2138.61
Motomiya-city	22,600	1.58	-1210.74
Nihonmatsu-city	27,338	2.15	-1992.93
Sukagawa-city	29,413	0.44	-438.812
Shirakawa-city	22,101	0.59	-442.131
Tamura-city	16,991	0.23	-132.505
Kitakata-city	25,350	0.2	-171.907
Aizuwakamatsu-city	35,497	0.2	-240.718
Koriyama-city	55,414	1.16	-2179.54
Iwaki-city	34,081	0.28	-323.562
Kunimi-town	15,675	0.8	-425.191
Koori-town	22,793	1.33	-1027.87
Kawamata-town	19,167	1.16	-753.874
Shinchi-town	13,250	0.44	-197.677
Miharu-town	26,467	0.53	-475.628
Ono-town	17,900	0.25	-151.733
Hanawa-town	22,067	0.28	-209.502
Tanagura-town	25,000	0.36	-305.161
Asakawa-town	22,633	0.26	-199.527
Ishikawa-town	25,400	0.31	-266.982
Kagamiishi-town	21,600	0.41	-300.279
Yabuki-town	25,967	0.31	-272.942
Minamiaizu-town	13,513	0.13	-59.5637
Nishiaizu-town	11,930	0.09	-36.4057
Aizumisato-town	14,714	0.21	-104.77
Aizubange-town	26,033	0.23	-203.02
Inawashiro-town	20,900	0.18	-127.557

Bandai-town	11,825	0.22	-88.2085
Otama- village	15,100	1.12	-573.432
Hirata- village	7,245	0.22	-54.044
Tamakawa- village	10,280	0.27	-94.1117
Izumizaki- village	12,500	0.18	-76.2903
Nishigo- village	30,267	0.73	-749.168
Nakajima- village	11,125	0.34	-128.252
Yugawa- village	7,885	0.3	-80.2065
Average			-487.244

Table 5 Radiation effect for land price in each municipals of Miyagi

Municipal	Average land price (Yen per ㎡)	Average radiation amount(μSv per hour)	Radiation effect(Yen per ㎡)
Miyahino-district	75,612	0.14	-358.927
Wakabayashi-district	92,006	0.12	-374.355
Izumi-district	65,368	0.09	-199.478
Taihaku-district	58,278	0.11	-217.362
Aoba-district	242,742	0.09	-740.754
Kesennuma-city	28,650	0.19	-184.572
Tome-city	14,134	0.09	-43.131
Kurihara-city	17,193	0.2	-116.592
Ishinomaki-city	29,723	0.07	-70.547
Osaki-city	27,661	0.11	-103.169
Higashimatsushima-city	25,825	0.07	-61.295
Shiogama-city	37,444	0.08	-101.568
Tagajo-city	49,821	0.1	-168.927
Natori-city	44,656	0.12	-181.697
Iwanuma-city	36,125	0.15	-183.732
Kakuda-city	22,900	0.41	-318.351
Shiraishi-city	28,150	0.27	-257.709
Onagawa-town	12,295	0.13	-54.195
Wakuya-town	19,733	0.07	-46.836
Misato-town	20,967	0.07	-49.765
Kami-town	25,833	0.11	-96.351
Matsushima-town	29,700	0.07	-70.492
Osato-town	13,550	0.07	-32.161
Shichigahama-town	33,767	0.11	-125.942
Rifu-town	33,200	0.09	-101.314
Tomiya-town	34,367	0.07	-81.569

Taiwa-town	21,575	0.07	-51.208
Kawasaki-town	15,767	0.11	-58.807
Zao-town	15,533	0.13	-68.468
Murata-town	16,500	0.18	-100.703
Ogawara-town	35,167	0.24	-286.176
Shibata-town	32,000	0.22	-238.704
Watari-town	30,433	0.21	-216.696
Yamamoto-town	12,950	0.21	-92.210
Marumori-town	16,767	0.38	-216.036
Ohira-village	21,700	0.07	-51.504
Average			-158.925