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Hedonic analysis of land contamination and information: A case study of 23 wards in Tokyo, Japan

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1 Introduction

Various environmental problems are still being addressed in the world today, some of which are macroscopic issues such as climate change and ocean plastic pollution, while others are microscopic issues such as air pollution and noise. Soil contamination is one such microscopic environmental problem.

Some studies have shown that soil contamination reduces the prices of nearby properties in terms of environmental amenity assessment [3], [6], [10], [11], [13]. According to Walsh [22], these soil-contamination studies can be interpreted as improving the information asymmetry between buyers and sellers by providing neighbors with information about the presence of contaminated soil. In other words, the hedonic approach assumes perfect information, but if the information about environmental risks is asymmetric, then the real-estate price does not reflect their revealed preference correctly, and providing information will lead to the correct price. Several studies, mainly in the U.S., have shown that the presence of contaminated soil may affect risk perceptions even when it does not pose a health risk, but the impact of this information varies in magnitude depending on time and place. Therefore, hedonic analyses of the disclosure of information on soil contamination are needed in many cases, but there have been few studies on the hedonic approach to soil contamination in Japan. Therefore, the present study examines the impact of soil-contamination disclosure on real-estate prices in Tokyo, Japan.

In Japan, the Agricultural Soil Pollution Control Act and the Water Pollution Control Act were promulgated in 1970 as laws related to soil contamination. The former is a law to prevent health hazards caused by specific hazardous substances in agricultural land, and it covers soil contamination by cadmium, copper, and arsenic; the latter is a law to prevent water pollution in public water bodies, which ultimately prevents soil contamination. The Water Pollution Control Law regulates wastewater discharged from factories and facilities and sets regulation levels for 28 hazardous

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substances and items related to the living environment. Therefore, there was no law to deal with soil contamination occurring in urban areas until the Soil Contamination Countermeasures Act (SCCA) was promulgated in 2002. The background to the SCCA was the acquisition of land by foreign companies in the 1990s and the resulting demand for soil surveys. It requires that land found to be contaminated be declared a "designated area" and that the intake route is blocked. Once the intake route is blocked, there is no legal requirement to remove the contamination. However, market demand required landowners to carry out expensive excavation work to return the soil to a problem-free state by transporting the contaminated soil to another location for soil remediation. In 2009, a revised law was promulgated to reduce the amount of expensive excavation work by classifying soil contamination into two categories: (i) "areas requiring measures," which pose an immediate health risk, and (ii) "areas requiring notification at the time of change in form," which pose no immediate risk. This revision clarified health risks and the need for cleanup measures.

The present study adopted a hedonic approach using traded real-estate data, publicly available soil-contamination data, and facilities reporting Pollutant Release and Transfer Register (PRTR) data from 2010 to 2019 in Tokyo. Specifically, it adopted a difference-in-differences approach and an event-study approach: the former examined how real-estate prices have been affected by disclosing information under the SCCA using a straightforward method; on the other hand, because information can be disclosed at any time, the latter approach was also adopted to examine the effect of such disclosure more precisely.

This analysis yielded three main results. First, housing prices increase in neighborhoods with soil contamination that does not pose a health risk, whereas they remain unchanged with soil contamination that poses a health risk. Second, the event-study results confirm that each coefficient is not statistically significant before the information is released. This result indicates that the existence of factories and facilities that are the sources of soil contamination does not have a negative externality before the information is disclosed, and that real-estate prices suggest that the parallel-trends assumption is satisfied. Finally, if we limit the sample to only the area around the PRTR-reported sites, then the absence of prior real-estate price decreases suggests that residents in the vicinity may be aware of the negative externalities and reflect them in real-estate prices. In addition, when purchasing land and houses, information about the absence of health hazards may increase real-estate prices by guaranteeing safety.

The structure of this paper is as follows. Section 2 gives an overview of the SCCA, and Section 3 summarizes previous literature. Section 4 describes the model and data that were used, and Section 5 presents the results. Finally, conclusions are drawn in Section 6.

2 Background

The SCCA was promulgated in 2002 and first enforced in 2003. This law aims to protect people's health and block the pathways of health hazards caused by direct and indirect soil contamination. Twenty-six types of substances that may cause health hazards and are subject to regulation are designated as having the potential to cause human health hazards. It is assumed that these substances will be ingested directly via soil dust or by groundwater leached into the soil. Under the SCCA, the following steps are taken: (i) conduct a soil-contamination survey; (ii) designate an area and prepare a register if the soil contamination exceeds the designated standards; (iii) manage the area; (iv) cancel the designation when the reasons for designation no longer exist.

The SCCA stipulates that soil surveys are conducted following Articles 3, 4, 5, and 14. Article 3 stipulates that the survey should be conducted when the use of the specified facility that uses hazardous substances is discontinued, and the survey should be conducted when the operation of the factory site that handles hazardous substances that may be contaminated is stopped. Article 4 specifies that the investigation should be triggered at the time of a change in the shape of land above a certain size, and that prior notification is obligatory for changes in the shape of the land of 3000 m^2 or more, and that an investigation order will be issued if an authority such as the prefectural governor determines that there is a risk of contamination. Under Article 5, a survey order will be issued if the prefectural governor determines that soil contamination is likely to cause damage to human health. In addition, Article 14 allows landowners to voluntarily conduct a soil-contamination survey and apply for a zone if contamination is found.

The outline of the designation of zones is as follows. The first criterion for designating an area is whether it is subject to regulation, based on whether the amount of soil elution or soil content exceeds the standard for hazardous substances[1] specified by law. Next, depending on whether the soil contamination poses a health risk, the area is designated as an “area requiring action” (hereinafter referred to as hazardous) if measures such as decontamination are necessary, or as an “area requiring notification at the time of change in form” (hereinafter referred to as harmless) if such measures are not necessary. For each zone designation, the government discloses information such as the location and the state of soil contamination. The specific survey procedures are as follows: (1) a land-history survey, (2) a surface soil survey, (3) an individual survey (a soil survey for each mesh or unit plot to check the spread of contamination on a flat surface), (4) a detailed survey (a borehole survey of 10 m), and (5) soil purification work. If the standard value is exceeded at point (2), then the area is designated as a contaminated area.

If the area is designated as hazardous, then the landowner must take measures as specified by law to block the intake route within the time limit specified by law: if the intake route is via groundwater, then the owner must measure the quality of the groundwater and contain it; if the intake route is direct intake, then the owner must fill the area.

On the other hand, if the area is designated as harmless, then no measures such as decontamination are required because there is no route for ingestion of soil contamination and there is no risk of health damage. The government directs the

[1] This classification is based on volatile organic compounds (class 1), heavy metals (class 2), and pesticides and PCBs (class 3).

removal of soil contamination (removal by excavation or restoration) in only a few cases, these being limited to those such as when soil contamination is found in a sandbox used as a playground for children. However, in some cases, landowners voluntarily carry out excavation removal because they can choose the decontamination measures to be implemented from among those that are considered to have the same or better effect than the indicated measures. In the case of a hazardous area, the designation is lifted when the intake route of contamination is blocked, after which the area is designated as harmless. In the case of a harmless area, for the designation to be lifted, the contaminated soil must be removed by excavation or by chemical or microbial remediation As a result of soil-contamination surveys, more areas are designated as harmless than hazardous. In most years, only about 20 areas were designated as ones requiring special measures, but at least 25 and generally about 120 were designated as harmless areas.

3 Literature review

Empirical studies of environmental pollution and housing prices have focused on three major themes, namely, (1) the existence of disamenity, (2) the discovery and disclosure of contamination, and (3) remediation. In the first theme, the analysis of disamenity estimates the negative impact of the location and opening of factories and waste disposal sites by measuring people's willingness to pay for pollutant emissions. The second theme involves topics that focus on the change in real-estate prices due to improved information asymmetry. The third theme examines for how long stigma persists even after soil contamination has been physically removed by cleanup.

Mentioned herein are some studies of the impact of the presence of disamenity on real-estate prices [5], [6], [9], [14], [15], [18]. Hite et al. [5] found that the presence of landfills has a long-lasting effect on the prices of surrounding properties. Ihlanfeldt and Taylor [6] showed that soil contamination reduces the prices of single-family homes and lowers land prices in commercial and industrial areas. Kiel and Williams [16] suggested that the effect of the National Priorities List (NPL) listing in the reduction of real-estate prices has heterogeneity with respect to time and region. Kiel [14] analyzed the impact on real-estate prices of the location and toxicity of two Superfund-law contaminated areas and the disclosure of information about cleanup operations. Their analysis showed that prices decreased with distance from the site before the release of information, but there was also a statistically significant decrease in prices after the release of contaminated information and after an agreement to conduct cleanup work. Their interpretation mentions that the stigma effect exists in the form that information on cleanup operations is not communicated to residents and is not trusted.

Also, there have been several studies of pollution disclosure [1], [17], [21]–[23]. For example, Kohlhase [13] found that real-estate prices decline when soil-contaminated areas are placed on the U.S. Environmental Protection Agency's NPL, and the farther from the contaminated area, the smaller the decline. Currie et al. [1] also found that the operation and closure of a plant emitting hazardous substances were associated with lower house prices and higher instances of low birth weight in a onemile radius of the plant. Wisinger [17] focused on the heterogeneity in the impact of different types of public information on house prices, with some areas of soil contamination being publicly available on the Internet and others not, depending on the severity of the contamination. Walsh and Mui [16] analyzed the impact of real-estate sellers' obligation to disclose information about soil contamination on housing prices through a property disclosure law enacted in New Jersey in 2004. They concluded that home prices did not decrease after the disclosure law in neighborhoods where soil contamination was already widely known, and that the disclosure requirement increased prices by correcting incomplete information among real-estate traders. Taylor et al. [21] analyzed the effects of the presence of waste treatment plants and their cleanup operations and argued that by using the non-polluted commercial land effect as a comparison, a clear stigma effect can be identified. Their results show that the stigma effect is not identified significantly, and that non-polluted commercial areas and remediated polluted experienced areas have similar real-estate prices.

Finally, there have been studies related to the stigma effect of psychological defects and the increase in real-estate prices due to soil remediation efforts [3]–[5], [16]. These studies examined how long aversion persists. Kiel and Williams [16] suggested that the effect of NPL listing in the reduction of real-estate price has heterogeneity with respect to time and region. Guignet et al. [5] analyzed the effects of storage-tank spills across the U.S., assuming that differences arise depending on the notoriety of the accident. They showed an average price decline of 2%–6% within 2–3 km of the accident and a price increase of 4%–9% after cleanup operations, suggesting that stigma effects may not be present. Gamper and Timms [3] tested whether removal from the NPL restores real-estate prices by giving people the information that soil contamination removal is complete. Their analysis also reveals that the effect of increased real-estate prices due to remediation work is regionally heterogeneous. Greenstone and Gallagher [4] used regression discontinuity designs to analyze the impact of hazardous-waste site cleanups on regional economic welfare. By comparing treatment plants that are listed in the NPL with those that are not listed and are not selected, they concluded that the impact on real-estate prices, rents, and housing supply is very small and that the benefits of remediation work in the real-estate market are small.

Several studies have examined the impact of externalities on real-estate prices in Japan with a hedonic approach [7], [10], [11], [24]. Kawaguchi and Yukutake [11] and Yukutake and Sugawara [24] analyzed the short-term and long-term effects, respectively, of radioactive contamination caused by the Great East Japan Earthquake on housing prices. Hibiki and Managi [7] used public land prices to analyze people's reaction to facilities emitting specific hazardous substances. They found that residents living within 1 km of the handling of chemical substances decreased their rents because of the perceived carcinogenic risk. Kang et al. [10] analyzed the relationship between air-pollution concentrations and official land prices and found that air pollution has a negative impact on official land prices.

However, there have been few Japanese studies of the impact of soil contamination other than radiation on real-estate prices. Takahama and Kawase [20] analyzed the impact of the designation of contaminated areas by the SCCA in Tokyo on public land prices, but that analysis was a cross-sectional one, and bias remained due to unobservable properties specific to the area.

This analysis examines the impact of the SCCA on real-estate transactions in Tokyo. Unlike Kawase and Takahama [12], who used cross-sectional analysis, the present study adopts difference in differences. The present soil contamination occurred before the area was designated as contaminated, therefore the residents may have known about the soil contamination before the information about the designation of the contaminated area by the government was made public, and that knowledge would have had a negative impact on the prices of real estate traded before the designation. In the case of hazardous areas, there will be a positive impact on real-estate prices because the government will take some measures to guarantee the safety of the area. On the other hand, in the case of harmless areas, there may be no impact on real-estate prices because residents already know about contamination and safety.

4 Data and descriptive statistics

The data on areas designated as contaminated were collected from the Ledger Information Disclosure System Based on the SCCA.[2] This system began in 2003 and provides data on designation, location, and soil-contamination status. With the amendment of the SCCA in 2018, information on soil-contamination cancellation is also available. The listed contaminated location is the land number in which the designated mesh exists; a land number is a number assigned to each piece of land, and it is necessary to refer to the address notation in order to obtain accurate location information. Takahama and Kawase [19] assigned coordinates based on the land-number information obtained from the system, but because the same method could not be used in the present study, coordinates were assigned in address units instead.

The data on real-estate prices were collected from the Real Estate Transaction Prices provided by the Ministry of Land, Infrastructure, Transport and Tourism. These data are a quarterly record of a questionnaire survey of people involved in real-estate

[2]https://wwwdojou.kankyo.metro.tokyo.lg.jp/SoilPollution/Search/Search/BulkSearch

[3]https://www.meti.go.jp/policy/chemical_management/law/prtr/6a.html

(a) (b)

Figure 1. Points of soil contamination: (a) areas for which changes to form or nature require notification (harmless); (b) areas that require measures (hazardous).

transactions conducted, and they include the transaction price of real estate, area, the age of the building, the use classification, the travel time to the nearest station, and the floor area ratio. To maintain anonymity, the locations can be narrowed down to only district, not property and room, therefore a panel data set could not be created for each property.

The data on PRTR-reported facilities were collected from the Publication of Reported Data under the PRTR system[3] by the Ministry of Economy, Trade and Industry. Japan has enforced the PRTR system since 2001, which requires facilities with 21 or more employees that produce or use chemical substances that are potentially hazardous to the environment to estimate the amounts released and transferred in waste and report the data to their local governments. While the information on soil-contamination designation is available on an address basis, real-estate transactions are available only per town/district. Therefore, the present study examined whether real estate was traded within a certain range from the address corresponding to the lot number designated as soil contamination. Because the areas designated as soil contamination and the points of real-estate transactions and public land prices do not necessarily indicate the same points, real estate within a certain range from the areas designated as soil contamination was treated as the subject property. This analysis used a dummy variable for real estate traded within 500 m of facilities that handle chemical substances, assuming that this is a factor in recognizing the risk of soil contamination; the dummy variable was set to one if the business establishment had submitted a notification at the timing when the real-estate transaction took place, or zero otherwise. The data on soil-contamination designated areas, real-estate prices, and PRTR sites were then combined to create a data set. In this study, a soil-contamination dummy was set to one if a real-estate transaction took place within 1 km of a designated soil-contamination area, and a PRTR dummy was set to one if a real-estate transaction took place within 500 m of a PRTR reporting site. The rationale for this distance was based on previous research [2], [7]. Referring to Hibiki and Managi [7], it was assumed that residents within 1 km are aware of the health hazards of soil contamination, and that those within 500 m are concerned about a chemical hazard. The Ministry of Environment [2] also suggests 1 km as the distance that groundwater contamination could reach.

After compiling the data for this study, the region was limited to only the 23 special wards of Tokyo[3] because real estate appraisal values differ between areas inside and outside of these wards.

Figure 1 plots the areas designated as having contaminated soil. There were 941 such areas between 2010 and 2019, and their breakdown is 98 hazardous points requiring measures (light blue) and 843 harmless points requiring notification (orange).

Table 1 gives the descriptive statistics for the data. These data cover real-estate transactions in Tokyo from 2010 to 2019, excluding island areas. The average price is approximately 680,000 yen over the whole sample, the average property is 15 years old and has a floor area of 300 m^2, and the average time to the nearest station is 8 min. In Japan, there is a category of land use called “use districts,” and 34% of the areas are limited to commercial areas and 17% are limited to industrial areas. Table 1 also provides statistics by dividing the sample into designated hazardous areas, harmless areas, and non-designated areas. Some samples have negative values for year of construction, but these are considered cases in which the sales contract was concluded earlier than the real-estate transaction.

5 Identification strategy

Hedonic analysis was used to estimate the impact of the SCCA’s zoning on real-estate transaction prices. The estimation equations were

$$\log P_{ijt} = \alpha + Hazardous_{ijt}\beta_1 + Harmless_{ijt}\beta_2 + X_{ijt}\beta_3 + c_j + \gamma_t + \epsilon_{ijt}, \quad (1)$$

$$\log P_{ijt} = \alpha + \sum_{l=-14}^{9} \beta_l Hazardous_{l,ijt} + \sum_{k=-14}^{9} \beta_k Harmless_{k,ijt} + X_{ijt}\beta_3 + c_j + \gamma_t + \epsilon_{ijt}, \quad (2)$$

[3] Tokyo is comprised 23 wards, 26 cities, 5 towns, and 8 villages. The eastern area of Tokyo consists entirely of wards, the western area consists of 26 cities and 3 towns, and the remaining towns and villages are islands.

Table 1. Descriptive statistics.

Variables	Mean	SD	Min	Max
Full sample(N=244,803)				
Price per m^2(Yen)	72934.99	693619.59	45.71	38271604.94
Hazardous	0.02	0.13	0.00	1.00
Harmless	0.11	0.32	0.00	1.00
Pre disclosure	0.44	0.50	0.00	1.00
Year of construction	15.71	14.14	-2.00	74.00
Total floor space(m^2)	323.33	159.42	60.00	1.30
Distance to station(min)	7.85	4.91	0.00	29.00
Commercial zone	0.38	0.48	0.00	1.00
Industrial zone	0.19	0.39	0.00	1.00
Hazardous (N=4,065)				
Price per m^2(Yen)	734035.92	409650.12	20000.00	7500000.00
Year of construction	16.17	14.11	-1.00	69.00
Total floor space(m^2)	326.65	154.66	60.00	800.00
Distance to station(min)	7.57	4.47	0.00	29.00
Commercial zone	0.38	0.49	0.00	1.00
Industrial zone	0.17	0.38	0.00	1.00
Harmless (N=27,869)				
Price per m^2(Yen)	841387.37	783603.61	11076.92	34000000.00
Year of construction	16.76	14.24	-2.00	71.00
Total floor space(m^2)	351.71	161.90	60.00	1100.00
Distance to station(min)	7.29	4.65	0.00	29.00
Commercial zone	0.42	0.49	0.00	1.00
Industrial zone	0.20	0.40	0.00	1.00
Nerver contaminated (N=214,818)				
Price per m^2(Yen)	764459.56	682813.60	45.71	38271604.94
Year of construction	15.57	14.12	-2.00	74.00
Total floor space(m^2)	319.64	158.77	60.00	1300.00
Distance to station(min)	7.93	4.94	0.00	29.00
Commercial zone	0.37	0.48	0.00	1.00
Industrial zone	0.19	0.39	0.00	1.00

where P_{ijt} is the price per area (yen/m^2) of property i in city/town j and year t, and X_{ijt} gives the property characteristics using building age, floor area ratio, time to nearest station, and zoning dummy. $Hazardous_{ijt}$ and $Harmless_{ijt}$ are indicator variables that take the value one if the property is within a certain distance from the land number designated by the SCCA and zero if the property is not within a certain distance: if the information suggests that there is an immediate health risk, then $Hazardous_{ijt}$ (because the area within 1 km is designated an area requiring special measures) takes the value one; if the information suggests that there is no immediately health risk, then $Harmless_{ijt}$ (because the area within 1 km is designated as one for which changes in form or nature require notification) takes the value one.

This study also examined risk perception by including $Predisclosure_{ijt}$ and $PRTR_{ijt}$ as explanatory variables. The dummy variable $Predisclosure_{ijt}$ is set to one if the area is not designated as a soil-contamination area in year *t* but is designated thereafter. Real-estate agents and neighbors may be aware of soil-contamination sources and share information about them before soil contamination is identified; in that case, this variable was included because real-estate prices are expected to be relatively low even before the information about soil contamination is disclosed. Furthermore, the term c_j is the time-invariant fixed effect of the city, γ_t is the year fixed effect, and ε_{ijt} is the error term. To account for heterogeneity with respect to the impact of soil-contamination disclosure on real-estate transaction prices, in the estimation equations, $PRTR_t$ is a dummy variable that takes the value one if the site is contained within a certain radius of a facility that has submitted a notification of the handling of hazardous substances in year *t* according to the PRTR notification system. The impact of the disclosure of soil-contamination information may be different if the facilities handling the specific hazardous substances that cause soil contamination are located near the real-estate property. In particular, if real-estate agents and residents in the vicinity are aware that facilities handling hazardous substances that cause soil contamination are located in the vicinity of the real-estate property even before the soil survey, then the real-estate price may decrease even before the disclosure of information on soil contamination.

In equation (2), β_l and β_k are the event-study dummies, and the other variables are the same as in equation (1). The point estimates $\hat{\beta}_l$ and $\hat{\beta}_k$ are the coefficients of interest, measuring the logarithmic difference in real-estate prices traded *l* or *k* years, respectively, after the area was designated as a soil-contamination area.

6 Results

6.1 Results of difference in differences

Table 2 gives the results of the fixed-effects model when a real-estate transaction takes place within 1 km of an area designated under the SCCA. The first column gives the results for all real-estate properties (used condominiums, residential land with houses), the second column gives the results for only used condominiums, and the third column gives the results for only residential land with houses, with the sample limited to these properties.

The results in the first column indicate that the risk variable (hazardous) is not significant whereas the non-risk variable (harmless) is positive and significant at the 90% level, suggesting that the risk information yielded increasing property prices. The second and third columns contain separate samples of different types of real estate. The second column, analyzing only used condominiums, shows that hazardous and harmless are not significant. The third column, analyzing only residential land with houses, also shows that hazardous is not significant whereas harmless is positive and significant at the 90% level. The results in the third column show that, as in the first column, information suggesting the existence of health risks does not affect real-estate prices, but information suggesting safety has the effect of increasing them. The difference in the magnitude of impact by type of building may be due to the fact that in a house, the land is also purchased together with the house, whereas in a used condominium, the buyer is less concerned about soil contamination because of the distance from the ground surface.

Table 2. Baseline.

	Total	Used Condominum	House with Land
Hazardous	0.000	-0.002	-0.015
	(0.008)	(0.008)	(0.010)
Harmless	0.008+	0.005	0.010+
	(0.004)	(0.004)	(0.006)
Building age	-0.017***	-0.022***	-0.018***
	(0.001)	(0.001)	(0.001)
Floor area ratio	0.001***	0.000**	0.002***
	(0.000)	(0.000)	(0.000)
Station time	-0.017***	-0.013***	-0.017***
	(0.001)	(0.001)	(0.001)
Business	0.010	-0.016	0.098***
	(0.014)	(0.012)	(0.024)
Industry	-0.005	-0.043*	-0.010
	(0.022)	(0.020)	(0.022)
Num.Obs.	244803	157381	87422
Adj. R2	0.523	0.629	0.654
FE:municipality	Yes	Yes	Yes
FE:year	Yes	Yes	Yes

Note: +, *, **and *** indicate that the coefficient is significantly different from 0 at 10%, 5%, 1% and 0.1%, respectively. Standard errors in parentheses are robust for clustering at the municipality level.

Table 3. Pre-disclosure and PRTR.

	Total	Used Condominum	House with Land
Hazardous×PRTR	0.025	0.032	-0.021
	(0.023)	(0.021)	(0.027)
Harmless×PRTR	0.023*	0.016*	0.069***
	(0.008)	(0.007)	(0.013)
Pre disclosure×PRTR	-0.021*	-0.014*	-0.092***
	(0.009)	(0.007)	(0.019)
Hazardous	-0.005	-0.011	-0.011
	(0.009)	(0.008)	(0.011)
Harmless	0.001	-0.002	-0.004
	(0.004)	(0.004)	(0.006)
Pre disclosure	0.002	0.003	0.000
	(0.004)	(0.002)	(0.004)
PRTR	0.010	-0.003	0.052**
	(0.011)	(0.009)	(0.014)
Building age	-0.017***	-0.022***	-0.018***
	(0.001)	(0.001)	(0.001)
Floor area ratio	0.001***	0.000**	0.002***
	(0.000)	(0.000)	(0.000)
Station time	-0.017***	-0.013***	-0.017***
	(0.001)	(0.001)	(0.001)
Business	0.010	-0.016	0.098***
	(0.014)	(0.012)	(0.024)
Industry	-0.005	-0.043*	-0.010
	(0.022)	(0.020)	(0.022)
Num.Obs.	244803	157381	87422
Adj. R2	0.523	0.629	0.654
FE:municipality	Yes	Yes	Yes
FE:year	Yes	Yes	Yes

Note: +, *, **and *** indicate that the coefficient is significantly different from 0 at 10%, 5%, 1% and 0.1%, respectively. Standard errors in parentheses are robust for clustering at the municipality level.

Table 3 analyzes the impact on real-estate prices with the PRTR and pre-disclosure dummies. The pre-treatment dummy (pre-disclosure) variable refers to land in which contamination exists but has not been detected because it has not been investigated.

This variable assumes the presence of facilities and residents' insecurity that contribute negative externalities, such as emitting pollutants or causing noise. The PRTR dummy variable indicates heterogeneity in the presence of potential soil contamination sources in the neighborhood. This variable captures the possibility that the presence of chemical emitting establishments in the vicinity of the real estate makes residents more responsive to pollution information and the possibility of prior perception through informal information such as rumors. The results in Table 3 show that hazardous is not significant in single terms and cross terms. The single term of PRTR sites has a significantly positive impact on real-estate prices in the case of land with houses, which may be a surrogate for relatively high real-estate prices due to the commercial and industrial prosperity around PRTR facilities. None of the single terms hazardous, harmless, and pre-disclosure are significant. In cross terms, harmless has a significantly negative impact on real-estate prices in areas where soil contamination will be found in the future (pre-disclosure×PRTR) and a positive impact on them when the area is designated as harmless (harmless×PRTR). These results suggest that the negative externality for undetermined contamination and relief from removal of contamination may be limited to the vicinity of the PRTR facility. The hazardous cross term is not significant.

Table 4. PRTR sample only.

	Total	Used Condominum	House with Land
Hazardous	0.033	0.023	-0.008
	(0.019)	(0.018)	(0.029)
Harmless	0.013+	0.007	0.032*
	(0.007)	(0.007)	(0.013)
Pre disclosure	0.013	0.004	0.003
	(0.008)	(0.005)	(0.017)
Building age	-0.014***	-0.021***	-0.016***
	(0.002)	(0.001)	(0.001)
Floor area ratio	0.000***	0.000	0.003***
	(0.000)	(0.000)	(0.000)
Station time	-0.017***	-0.013***	-0.025***
	(0.001)	(0.003)	(0.004)
Business	-0.039	-0.053+	0.030
	(0.033)	(0.029)	(0.063)
Industry	-0.070	-0.080+	-0.034
	(0.053)	(0.044)	(0.044)
Num.Obs.	48557	39143	9414
Adj. R2	0.328	0.553	0.619
FE:municipality	Yes	Yes	Yes
FE:year	Yes	Yes	Yes

Note: +, *, **and *** indicate that the coefficient is significantly different from 0 at 10%, 5%, 1% and 0.1%, respectively. Standard errors in parentheses are robust for clustering at the municipality level.

The results in Table 4 are those of the analysis restricting the sample to the PRTR vicinity. While previous results compared properties around the PRTR with others, this analysis compares properties around the PRTR. Table 4 shows that hazardous and pre-disclosure are not statistically significant, and harmless is positively significant in columns 1 and 3. Thus, negative externality before disclosure, such as anxiety about future pollution and noise associated with the operation of the business in the vicinity of the PRTR, were not identified as significant. On the other hand, disclosure of information that the property is safe was found notably to have a 3.2% price increase effective for the price of land with houses.

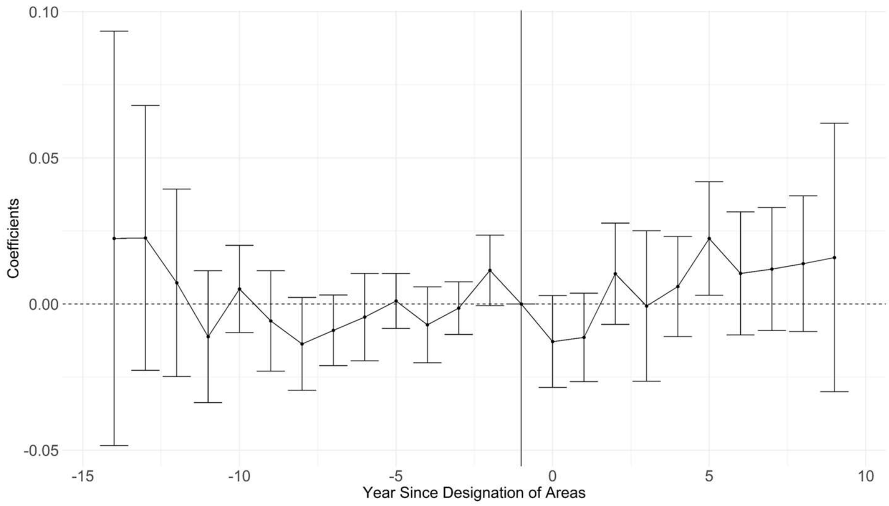
6.2 Robustness check

These results suggest that the disclosure of information on the designation of contaminated areas by the SCCA cannot be new information for real-estate buyers and sellers. Soil-contamination risks are recognized as available information and can be factored into real-estate prices. Instead, when information that there is no health risk is revealed as a result of soil surveys, real-estate prices tend to increase as the government takes on the role of guaranteeing safety. In this study, it was hypothesized that the presence of facilities handling specific hazardous substances would be a factor in people's perception of the soil-contamination risk. As a result, the price of real estate near the facility decreased with statistical significance, suggesting that people avoid the presence of the facility handling the specified hazardous substances. This result is because facilities are perceived to pose noise, air-pollution, and soil-contamination risks. Real-estate prices tend to increase as the government takes on the role of guaranteeing safety.

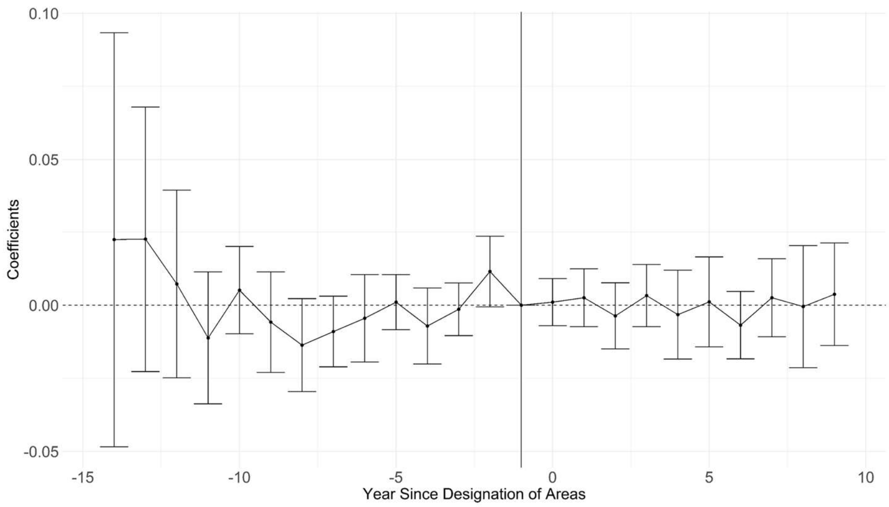
The SCCA has multiple timings for designating an area as having contaminated soil. Therefore, the event-study approach was also tried in addition to the difference- in-differences approach.

Figure 2 shows the results of the event-study analysis for used condominiums, limited to samples within 500 m of a PRTR site. Figure 2(a) shows the price response to information about hazardous health risks for used condominiums. The coefficients before information disclosure are not statistically significant, suggesting that the parallel-trends assumption is satisfied. In the following designation, the coefficient is negatively significant, suggesting that the information about the risk immediately after disclosure had the effect of depressing real-estate prices. Figure 2(b) similarly shows the price response to safety information for existing condominiums. This also shows satisfies the parallel-trends assumption.

Figure 2. Condominiums surrounding PRTR.



(a)　Hazardous

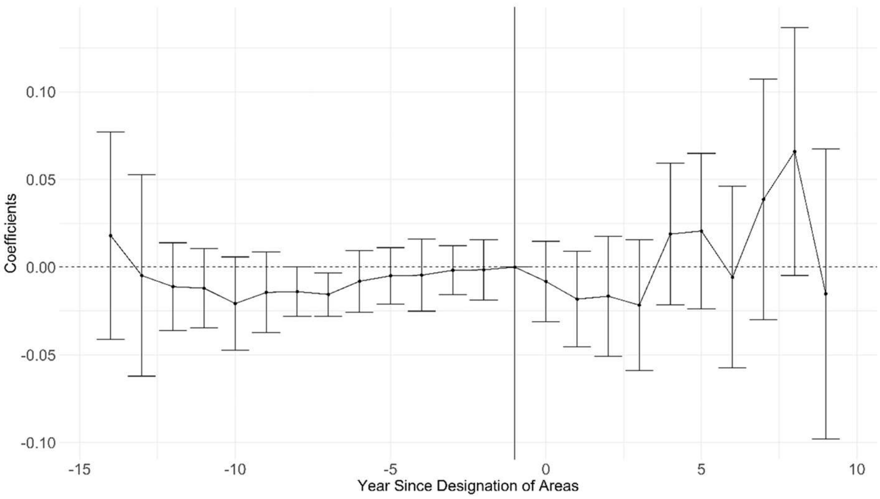


(b)　Harmless

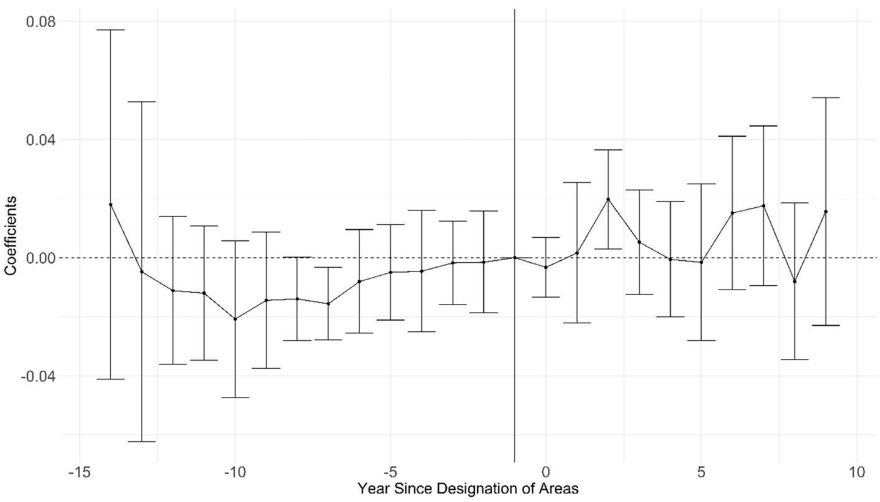
Figure 3(a) shows that the coefficients of information disclosure on adverse health risks are not statistically significant from 10 years ago. Thus, the parallel-trends assumption could be satisfied for land with houses near PRTR facilities. The data also show a significant decrease in prices after information disclosure. Figure 3(b) shows the event-study results for the harmless information. As in Figure 3(a), the parallel-trends assumption is also satisfied before disclosing the information. In addition, these coefficients are positive, uptrend, and statistically significant at the 3 years.

These results indicate that residents are unlikely to be aware of the risk of soil contamination even before the official disclosure of such information. Therefore, this analysis satisfies the parallel-trends assumption and the results of difference in differences are considered reliable.

Figure 3. Land with houses surrounding PRTR.



(a) Hazardous



(b) Harmless

7 Conclusion

By conducting a hedonic analysis in the wards of Tokyo, this study estimated the impact on real-estate prices when information is disclosed about soil contamination in the surrounding land. The analysis revealed that when soil-contaminated land exists within 1 km of a real-estate transaction, the price drops by between 1% and 10%. This effect varies in degree depending on the type of real estate (used condominiums, houses with land), and the event-study results showed that the pre-trend of information disclosure is not significant, the parallel-trends assumption is considered to be satisfied, and the heterogeneity between the PRTR neighborhood and the rest of the country is revealed. Therefore, the effects of information disclosure on soil contamination should be analyzed separately for areas around PRTR facilities and other areas.

The effects of information disclosure were discussed under either the existence or absence of immediate health hazards, depending on the content. Although information about immediate health hazards had no statistically significant effect on real-estate prices in the surrounding area, the results of the event study showed that it decreased prices considerably for about three years after information disclosure. In addition, the information that no immediate health hazards occurred was shown to increase the price of real estate in the surrounding area with statistical significance. In the event-study results, this effect is limited to land with houses, and the information that a property is safe may be of different value for different types of real estate.

These results suggest that the SCCA is functioning correctly, as real-estate transaction prices have increased by conducting soil surveys according to the SCCA and disclosing information that there is no risk of health hazards.

The area around the PRTR tends to have relatively high real-estate prices because it is a workplace for many people and locations with good accessibility are desirable. In such locations, the influence of information is also stronger, so both price decreases in the presence of negative externalities such as noise and price increases due to safety information may have more-pronounced effects. For such disclosed government information to impact correctly, residents must receive it. In particular, the objective of the 2009 amendment to the SCCA is considered to have been successful in that the information is communicated correctly to real-estate buyers by bringing the government's assurance that there is no risk of health damage; this is because of the communication of risk to residents near the soil survey.

For future work, the first issue is the possibility of sample-selection bias due to the real-estate transaction data, this being because real estate in less-desirable environments is cheaper, and more-frequent transactions cause bias in the estimation; a similar analysis using public land prices could solve this problem. The second issue is that this analysis has not identified the factors of negative externalities. The present study suggested that PRTR-reported facilities are unlikely to cause negative externalities, but future work will examine the heterogeneity of old buildings in contaminated areas and chemicals reported in the PRTR.

References

[1] Currie, Janet, Lucas Davis, Michael Greenstone, and Reed Walker (2015) "Environmental Health Risks and Housing Values: Evidence from 1,600 Toxic Plant Openings and Closings," *American Economic Review*, Vol. 105, No. 2, pp.

678–709, February, DOI: http://dx.doi.org/10.1257/aer.20121656rm 10.1257/aer.20121656.

[2] Ministry of the Environment Water, Ministry and Air Enviornmnt Bureau Soil Environment Division (2019) *Guidelines for Investigations and Measures Based on the Soil Contamination Countermeasures Act (Rivised 3rd ed.)*.

[3] Gamper-Rabindran, Shanti and Christopher Timmins (2013) "Does cleanup of hazardous waste sites raise housing values? Evidence of spatially localized benefits," Journal of Environmental Economics and Management, Vol. 65, No. 3, pp. 345–360.

[4] Greenstone, Michael and Justin Gallagher (2008) "Does Hazardous Waste Matter? Evidence from the Housing Market and the Superfund Program," *The Quarterly Journal of Economics*, Vol. 123, No. 3, pp. 951–1003, 08.

[5] Guignet, Dennis, Robin Jenkins, Matthew Ranson, and Patrick J Walsh (2018) "Contamination and incomplete information: Bounding implicit prices using high-profile leaks," Journal of environmental economics and management, Vol. 88, pp. 259–282.

[6] Ham, Yun-Ju, David J Maddison, and Robert JR Elliott (2013) "The valuation of landfill disamenities in Birmingham," Ecological economics, Vol. 85, pp. 116–129.

[7] Hibiki, Akira and Shunsuke Managi (2011) "Does the housing market respond to information disclosure?: Effects of toxicity indices in Japan," *Journal of environmental management*, Vol. 92, No. 1, pp. 165–171.

[8] Hite, Diane, Wen Chern, Fred Hitzhusen, and Alan Randall (2001) "Property-valueimpacts ofan environmentaldisamenity: thecase of landfills," *The Journal of Real Estate Finance and Economics*, Vol. 22, No. 2, pp. 185–202.

[9] Ihlanfeldt, Keith R and Laura O Taylor (2004) "Externality effects of small-scale hazardous waste sites: evidence from urban commercial property markets," *Journal of environmental economics and management*, Vol. 47, No. 1, pp. 117–139.

[10] Kang, Cheolmin, Mitsuru Ota, and Koichi Uchijima (2016) "Effects of Air Quality on Land Prices:Evidence from the Land Prices of Tokyo Metropolitan Area[Taikikankyou ga Chika ni Ataeru Eikyou:Tokyo-to Tokubetu-ku no Chika de-ta wo Mochiita Kensyou]," *Journal of Applied Regional Science*, No. 20, pp. 67–77.

[11] Kawaguchi, Daiji and Norifumi Yukutake (2017) "Estimating the residential land damage of the Fukushima nuclear accident," *Journal of Urban Economics*, Vol. 99, pp. 148–160.

[12] Kawase, Akihiro and Nobuaki Takahama (2019) “Dozyog Osen to Chika Keisei: Tokyo-to no Jirei [Soil Pollution and Land Price: The Case of Tokyo](in Japanese),” *Planning and public management [Keikakugyousei](in Japanese)*, Vol. 42, No. 3, pp. 42–50.

[13] Kent, Messer D., Schulze D. William, Hackett F. Katherine, Cameron A. Trudy, and McClelland H. Gary (2006) “Can stigma explan large property value losses? The psychology and economics of superfund,” *Environmental and Resource Economics*, Vol. 33, pp. 299–324.

[14] Kiel, Katherine A and Katherine T McClain (1995) “House prices during siting decision stages: The case of an incinerator from rumor through operation,” *Journal of Environmental Economics and Management*, Vol. 28, No. 2, pp. 241–255.

[15] Kiel, Katherine A and Katherine T McClain (1995) “House prices during siting decision stages: The case of an incinerator from rumor through operation,” Journal of Environmental Economics and Management, Vol. 28, No. 2, pp. 241–255.

[16] Kiel, Katherine A and Michael Williams (2007) “The impact of Superfund sites on local property values: Are all sites the same?” *Journal of urban Economics*, Vol. 61, No. 1, pp. 170–192.

[17] Kohlhase, Janet E (1991) “The impact of toxic waste sites on housing values,” *Journal of urban Economics*, Vol. 30, No. 1, pp. 1–26.

[18] Lavaine, Emmanuelle (2019) “Environmental risk and differentiated housing values: Evidence from the north of France,” Journal of Housing Economics, Vol. 44, pp. 74–87.

[19] Takahama, Nobuaki and Akihiro Kawase (2017) “Dozyou Osenchi ni Kansuru Chiri Kuukann Zyouhou no Seibi:Tokyo-to no Zirei[Development of geospatial information on soil contaminated land:Case Study of Tokyo](in Japanese),” *Planning and public management*, Vol. 40, No. 2, pp. 103–110.

[20] ——— (2019) “Houritsu ni yori Kuiki ni Shitei sareta Dozyou Osenchi ni okeru Tochi Riyou no Henka:Tokyo-to ni okeru Dozyou Osen Taisaku Hou no Sekou Zyokyo wo moto ni[Changes in Land Use in Legally Designated Soil Contaminated Areas: Based on the Enforcement of the Soil Contamination Countermeasures Law in Tokyo](in Japanese),” *Journal of environmental law and policy*, Vol. 22, pp. 174–187, 8.

[21] Taylor, Laura O, Daniel J Phaneuf, and Xiangping Liu (2016) “Disentangling property value impacts of environmental contamination from locally undesirable land uses: Implications for measuring post-cleanup stigma,” Journal of Urban Economics, Vol. 93, pp. 85–98.

[22] Walsh, Patrick and Preston Mui (2017) "Contaminated sites and information in hedonic models: An analysis of a NJ property disclosure law," *Resource and Energy Economics*, Vol. 50, pp. 1–14.

[23] Wisinger, Perry (2014) "Chemical hazardous sites and residential prices: Determinants of impact," *Journal of Sustainable Real Estate*, Vol. 6, No. 1, pp. 3–21.

[24] Yukutake, Norifumi and Satomi Sugawara (2017) "Measuring long-term effects of the Fukushima Daiichi Nuclear Power Plant accident on real estate prices," *Journal of Sustainable Real Estate*, Vol. 9, No. 1, pp. 3–21.