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Does the housing market respond to information disclosure?: Effects of toxicity indices in Japan

Akira Hibiki [a,*], Shunsuke Managi [b]

[a] Social and Environmental Systems Division, National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki 305-0044, Japan
[b] Graduate School of Environmental Studies, Tohoku University, 6-6-20 Aramaki-Aza Aoba, Aoba-Ku, Sendai, 980-8579, Japan

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ABSTRACT

The policy instruments that provide information on a firm's or facility's environmental performance, such as the U.S. Toxic Release Inventory (TRI) and the Pollutant Release and Transfer Register system (PRTRs) used in some European countries and Japan, play an important role in encouraging firms or facilities to improve their environmental performance, if investors, consumers and residents recognize their environmental performance. This study uses a hedonic approach to explore how the Japanese rental housing market responds to carcinogenic risk arising from releases and transfers of chemical substances produced and used at close facilities. We found that residents do not perceive carcinogenic risk generated more than 1.0 km away from their residence and that they seem to recognize the increased carcinogenic risk at distances from 0.5 km to 1.0 km away; a 1% increase in carcinogenic risk reduces the average rent by 0.0007%. The distance at which residents perceive the risk arising from such facilities is less than in previous studies. This suggests that the risk perception recognized in previous studies may capture the other externalities in addition to the chemical risk because the risk is measured by the distance.

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1. Introduction

In the past, governments rarely prioritized policies providing public information about the emissions of firms and facilities (hereafter we refer firms and (or) facilities as facilities for simplicity) that would help citizens avoid damage or harm resulting from those emissions. Governments collected extensive information on pollution emissions from several organizations, intended to help enforce minimum standards or to create financial incentives to reduce emissions and improve service quality (Breyer, 1993). Such information, however, was intended for expert use.

Public concerns about the management of emissions by facilities, corporate social responsibility, environmentally friendly products, and the adoption of certified environmental management systems have been increasing over the past several decades. Thus, policy instruments that provide information on a facility's environmental performance, such as the U.S. Toxic Release Inventory (TRI) and the Pollutant Release and Transfer Register system (PRTRs) in some European countries as well as Canada and Japan, play an important role in encouraging facilities to improve their environmental performance (see Cohen and Santhakumar, 2007).

For example, if investors use information on the firm's environmental performance to assess the value of the firm, they may value emissions negatively (for example, see Konar and Cohen, 2001). This is because investors expect that facilities with more emissions are more likely to be sued for damages due to emissions in the future, reducing the firm's future profit. If this is the case, the firm has an incentive to reduce emissions and thus attain a higher market valuation (see Hibiki and Managi, 2010 for further discussion). On the other hand, in the housing market, if residents care about the emissions of a facility because they are concerned about realized or expected damage, the provision of facility-specific environmental information, including location information, could influence the choice of the current residence location. Hence, the rent of houses and apartments that are closer to a facility with more emissions would become lower. The price of real estate closer to a facility with more emissions also becomes lower. Thus, facilities with more emissions are likely to face stronger pressure to reduce emissions, especially from landowners suffering capital loss.

It is an important empirical question to explore whether the market responds to publicly disclosed information about a facility's environmental performance. If the market did not respond to such information, the information provision policy would not

* Corresponding author. Tel.: +81 29 850 2510; fax: +81 29 850 2960.
E-mail addresses: hibiki@nies.go.jp, hibiki.akira.env.econ@gmail.com (A. Hibiki), managi.s@gmail.com (S. Managi).

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successfully incentivize facilities to improve their environmental performance.

The purpose of this study is to explore how the Japanese housing market responds to the risk to human health arising from release and transfer of chemical substances produced at close facilities. The study uses facility-level data on the release and transfer of chemical substances, which are available under the PRTRs in Japan.

Based on PRTRs information on the release and transfer of chemical substances produced and used at facilities, residents may choose not to live near facilities with many such releases and transfers to avoid risk to their health. For instance, they would want to avoid the possible damage due to future chemical spills that may happen at a particular facility. As a result, the rent of the houses and apartments near such facilities might decrease. On the other hand, if the information is complicated and difficult to use, or if residents are not interested in the chemical risk, such factors may not affect their choice of residence location, and the rent and the land price would not reflect the perceived health risk.

Previous studies explored how the housing market responds to chemical risk, measured as the distance from the property to the hazardous waste site (e.g., Kiel, 1995; Kohlhase, 1991; Nelson et al., 1992; Ihlanfeld and Taylor, 2004). It was found that property prices near hazardous waste sites are lower. However, these studies investigated the price–distance relationship rather than the price–risk (i.e., the risk calculated from releases and transfers of chemical substances) relationship. Therefore, they may not successfully measure willingness to pay for reduction of the chemical risk. In addition, these studies did not consider the risk level of the closest hazardous waste site, which depends on the quantity and type of chemical substances released and transferred. Moreover, they did not consider the total risk that the property faces because they only considered the effect of the risk from the closest site. It should be noted that to measure the total risk of a property, we should aggregate the risk from the multiple sites surrounding it. One exception is Ho and Hite (2008), who used cancer mortality as a proxy to control for carcinogenicity in the Southeastern U.S.[1] However, they did not consider difference in risk across the substances.

To address these problems, we explore the price–risk relationship with consideration of total risk from all the facilities surrounding the property.

The contribution of our paper is as follows:

(1) As a proxy for risk, we used a toxicity index calculated from data on the release and transfer of chemical substances in multiple facilities surrounding the property, rather than the simple distance from the nearest facility.
(2) To the best of our knowledge, there are no empirical analyses of the impact of the toxicity (but not distance) of chemical substances on nearby property values or on the housing market, and especially no studies on the Japanese market using information disclosed under PRTRs.
(3) The estimation results show that the risk perception recognized in previous studies may capture the other externalities in addition to the chemical risk.

This paper is organized as follows: Section 2 provides an overview of the Japanese PRTRs and previous studies; Section 3 explains the model; Section 4 describes the dataset and the variables used for the estimation; Section 5 presents empirical evidence; and Section 6 summarizes the conclusions.

[1] See Bartosová et al. (1999) for other applications such as flood risk.

2. PRTRs in Japan and previous studies

The OECD recommended that its member countries introduce the PRTR system in 1996. Based on this recommendation, Japan has enforced PRTRs[2] since 2001. PRTR enforcement requires that facilities with 21 or more employees that produce or use chemicals on a list of 354 substances specified by law[3] estimate the quantities of chemical substances released into the environment and transferred as waste and that they report the data to the central government via the prefectural governments. The central government aggregates and sorts out the reported data by type of industry as well as geographic region and then provides the results to the public.[4] The central government has to disclose data on individual facilities when requested by a citizen.[5]

There are previous studies exploring how the housing market responds to the distance between a property and a hazardous waste site. Previous studies show that the hazardous waste sites appearing on the EPA's National Priority List (NPL) and those listed by the state government were associated with lower nearby property values (Kiel, 1995; Kohlhase, 1991; Nelson et al., 1992; Ihlanfeld and Taylor, 2004). Kohlhase (1991) found that property prices closer to Superfund sites were not lower until after the sites were listed on the NPL in Houston. Gayer et al. (2000) looked at properties surrounding seven Superfund sites in Grand Rapids, Michigan and found that housing prices increased with distance from the closest Superfund site. Instead of looking at residential property, Ihlanfeld and Taylor (2004) explored the effects of hazardous waste sites on five classes of commercial and industrial property in Atlanta. They found that prices continued to rise up to a distance of at least two miles. Cameron (2006) developed a hedonic model that considered directional heterogeneity. Other relevant studies include those of Folland and Hough (2000), Gawande and Jenkins-Smith (2001), Hite et al. (2001), Brasington and Hite (2005), Zuindeau and Letombe (2008), and Kiel and Zabel (2001).

It should be noted that these studies may not successfully measure the chemical risk as we discussed in the introduction section.

3. Model and data

3.1. Model

Using PRTR data that have become available since the enforcement of PRTRs in 2002, we estimate a hedonic house rent model and investigate how the residents perceive the risk of chemical substances from nearby facilities.

[2] Important characteristics of a PRTR system are as follows: 1) facilities periodically send a mandatory report to the designated authorities on their chemical releases into the air, water, soil and waste. 2) Emission data specifying pollutants from individual facilities are accessible to the public.

[3] The complete title is "Law Concerning Reporting, etc. of Releases to the Environment of Specific Chemical Substances and Promoting Improvements in Their Management".

[4] The summary of the aggregated data is available at http://www.prtr.nite.go.jp/index-e.html.

[5] As for the socio–economic context, information release on PRTR has attracted peoples' attention. There are news stories on the releases. For example, a news search on the Yomiuri news website with keyword "PRTR" showed 109,107 hits on 2009/12/29. A simple news web search for "PRTR and housing" from the environmental news search engine *Environmental Information & Communication Network* (http://www.eic.or.jp/) has more than 300 entries. In addition, anyone can search for information on chemical releases and transfers from the ORCERC site (http://www.ecochemi.jp/PRTR.html). Over time, awareness of environmental risks has been increasing throughout the media and populace.

The hedonic house rent model[6] to be estimated in our study is expressed as follows[7,8]:

$$P_i = \alpha + \sum_{j=1}^{n} \beta_j \ln X_{ji} + \gamma_1 \ln \mathrm{RISKC05}_i + \gamma_2 \ln \mathrm{RISKC10}_i + \gamma_3 \ln \mathrm{RISKC15}_i + \gamma_4 \ln \mathrm{RISKC40}_i + \varepsilon_i$$

where P_i, X_{ji} and ε_i are the monthly rent of property i, jth characteristics of property i, including the floor space of the property, the age of the property, the distance to the nearest railway station, and error term, respectively. $\mathrm{RISK05}_i$, $\mathrm{RISK10}_i$, $\mathrm{RISK15}_i$ and $\mathrm{RISK40}_i$ are variables representing the chemical risk of the property i, and are described in detail in the data section.[9] It should be noted that we focus on property for rent but not property for sale, as in previous studies.

3.2. Data and variables

Data used in this analysis were from the rental housing market in Machida, a suburban area of Tokyo with around 390,000 residents.[10] There are 34 facilities in Machida that report releases and transfers of chemical substances listed for PRTRs. We did not choose the central Tokyo area for this study because the available observations in that area are located farther from facilities producing or using chemical substances, and thus we expect that the rent is not likely to reflect the chemical risk.

The risks generated from chemical substances were categorized into four types: carcinogenicity, mutagenicity, reproduction toxicity and sensitizing potential. In our study, we focused on carcinogenic risk because the residents are likely to care more about this risk.[11] Carcinogens affect humans through a variety of agents, mixtures and exposures. Information about proven and possible human carcinogens is needed to assess the hazards posed by exposure to chemical, physical and biological factors.

The Organization for Research and Communication on Environmental Risks of Chemicals (ORCERC) summarized the literature of risk analysis related to chemical substances in the PRTRs.[12] The carcinogenic risk information was collected from the following sources (see Table A of Appendix for risk factors):

(1) International Agency for Research on Cancer: IARC, Monographs on the Evaluation of Carcinogenic Risks to Humans (2003).
(2) European Union: EU, Council Directive 67/548/EEC Annex I, The Carcinogenicity Category (2002).
(3) United States Environmental Protection Agency: U.S. EPA, Integrated Risk Information System (IRIS) Evidence for Human Carcinogenicity Weight of Evidence Characterization (2003).
(4) United States National Toxicology Program: USNTP, The 8th Report on Carcinogens (2003).
(5) American Conference of Governmental Industrial Hygienists: ACGIH, 2003 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, Adopted Threshold Limit Value Appendix A Carcinogenicity.
(6) Ministry of Labor in Japan, Notification to Protect Health Disorder based on Section 28−3 on Labor Safety and Sanitation Law, Note for Health, Labor Standards Inspection Office (1999).
(7) Japan Society for Occupational Health, Recommendation for Permissible Concentration Table 3 Carcinogenic Substances, Japanese Journal of Occupational Health, Vol. 44, No. 4 (2003).

We constructed an index of carcinogenic risk by multiplying the risk factor by the amount of each chemical substance related to carcinogenic risk (see Appendix for detailed information). The data for the releases and transfers of individual chemical substances for each facility were obtained from the Japanese Ministry of the Environment. We considered the releases and transfers from all facilities that are likely to produce carcinogenic risk for an individual property. We also considered the difference in risk impact resulting from the difference in the distance from the individual property to the facilities. The index was constructed as follows:

(1) To calculate risk for each property, we considered the facilities located within 4 km of the property. We chose to do this because, as Ihlanfeld and Taylor (2004) discuss, residents are likely to perceive the risk from a site within 2 miles, or 3.2 km, from the property. Facilities surrounding each property were then categorized into four groups by their distance to the property. To consider the impact of chemical risk at various distances on the rent, the four groups of facilities were categorized as follows: those located less than 0.5 km away from the property; between 0.5 and 1.0 km away; between 1.0 and 1.5 km away; and between 1.5 and 4.0 km away. This categorization reflects several considerations: (a) we consider that damage by chemical toxicity would result from, for example, a serious accident at the facility; (b) the probability that residents would be affected by a serious accident depends on how far they live from the facility; and (c) even if the chemical toxicity at the source is the same, the damage depends on how far a resident lives from the facility.
(2) For each property, we tabulated the release and transfer of each chemical substance from the facilities in the same group.
(3) Using risk factors of each substance, we constructed a carcinogenic risk index for each group for each property. Thus, four indices for each property were constructed. We denote $\mathrm{RISKC05}_i$, $\mathrm{RISKC10}_i$, $\mathrm{RISKC15}_i$ and $\mathit{RISKC40}_i$ as the index of carcinogenic risk for property i in the area less than 0.5 km away from the property i, the area between 0.5 and 1.0 km, the area between 1.0 km and 1.5 km, and the area between 1.5 km and 4.0 km, respectively.

[6] See Freeman (1974), Rosen (1974), Farber (1998), Dale et al. (1999), Hidano (2002), Brasington and Hite (2005), and Zuindeau and Letombe (2008) for detailed information on the hedonic approach.

[7] It should be noted that the results depend heavily on model specification. Thus, we tried several different specifications, including a semi-log form. We find our specification to fit best and are able to interpret signs of each variable with statistical significance.

[8] The choice of functional form in hedonic pricing method has been a major concern due to the lack of guidance from economic theory about the intricate relationship between housing price and its multiple characteristics. See Ekeland et al. (2002, 2004) for detailed information. We appreciate the comment about this point from an anonymous referee.

[9] Knowledge plays an important role in behavior among individuals. For example, Hite (1998) found a large difference in behavior depending on whether or not an individual knows about the existence of a nearby landfill. Anstine (2003) also found significant effects when investigating how noticeable a pollution source is. Therefore, differences in levels of knowledge across individuals are likely to affect the rent. However, because of insufficient information regarding knowledge levels, our study did not consider this matter.

[10] Machida City is located about 30 km southwest of the center of Metropolitan Tokyo, adjacent to the border of Kanagawa Prefecture. The area of the city is 71.63 km^2, and the city has a population of about 390,000. The automobile parts and sheet-metal industries predominate in the city. Currently, new residential areas have been developed through regional planning. Environmental quality has been improved in the city. For example, the concentration of dioxin was reduced by about 34% from 2005 to 2008, based on reports from Machida municipal authorities (http://www.city.machida.tokyo.jp/kurashi/hozen_midori/cyousakekka/daiokekka/index.html).

[11] We also estimated the model using risk of mutagenicity, reproduction toxicity and sensitizing potential. However, none of the results were statistically significant.

[12] Information on chemical releases and transfers is from the ORCERC (http://www.ecochemi.jp/PRTR.html).

Table 1
Variables and definitions.

Variable	Unit	Name	Definition
P_i	10^3 Japanese Yen	Monthly rent of the property	Summation of the monthly rent, common-area charge and administrative maintenance fee
RISKC05$_i$	***	Risk of carcinogenicity (0.0–0.5 km) away from the property i	Carcinogenic risk in the area 0.5 km away from the property
RISKC10$_i$	***	Risk of carcinogenicity (0.5–1.0 km) away from the property i	Carcinogenic risk in the area between 0.5 km and 1.0 km away from the property
RISKC15$_i$	***	Risk of carcinogenicity (1.0–1.5 km away from the property i	Carcinogenic risk in the area between 1.0 km and 1.5 km away from the property
RISKC40$_i$	***	Risk of carcinogenicity (1.5–4.0 km) away from the property i	Carcinogenic risk in the area between 1.5 km and 4.0 km away from the property
Dis_Tokyo$_i$	Minutes	Distance between the closest station to the property *i* and Tokyo	Distance between the station closest to the property
Dis_station$_i$	Minutes	Distance between the property *i* and the closest station	Distance between the closest station (Shibuya or Shinjuku) of the JR Tokyo Loop Line
D_bus	***	Dummy of the usage of the bus	Equal to 1, if the bus is the most appropriate transportation means to go to the closest station from the property, and 0, otherwise.
Dis_ca	Km	Distance between property *i* and the nearest commercial area	
D_MachidaSt.	***	Dummy of Machida	Equal to 1, if the nearest commercial area from the property is Machida station area and 0, otherwise
TFS$_i$	m^2	Total floor space of the property *i*	
AGE$_i$	Months	Age of the property *i*	
Floor$_i$	***	Floor of the property *i*	
D_prk	***	Dummy of the parking	Equal to 1, if the property has parking and 0, otherwise
D_high	***	Dummy of the high-class apartment	Equal to 1, if the property is a high-class apartment and 0, otherwise
D_n	***	Dummy of the property *i* facing north	Equal to 1, if the property faces north and 0, otherwise
D_e	***	Dummy of the property *i* facing east	Equal to 1, if the property faces east and 0, otherwise
D_w	***	Dummy of the property *i* facing west	Equal to 1, if the property faces west and 0, otherwise
D_ne	***	Dummy of the property *i* facing northeast	Equal to 1, if the property faces northeast and 0, otherwise
D_nw	***	Dummy of the property *i* facing northwest	Equal to 1, if the property faces northwest and 0, otherwise
D_se	***	Dummy of the property *i* facing southeast	Equal to 1, if the property faces southeast and 0, otherwise
D_sw	***	Dummy of the property *i* facing southwest	Equal to 1, if the property faces southwest and 0, otherwise
D_wd	***	Dummy of the wooden structure	Equal to 1, if the property is wooden and 0, otherwise
D_st	***	Dummy of the steel structure	Equal to 1, if the property is of steel construction and 0, otherwise
D_pc	***	Dummy of PC structure	Equal to 1, if the property is of precast concrete structure and 0, otherwise
D_other	***	Dummy of other structure	Equal to 1, if the property is neither wooden, of steel structure, precast concrete structure nor light gauge steel structure and 0, otherwise
D_mi	***	Dummy of the music instruments	Equal to 1, if playing music instruments in the property is permitted and 0, otherwise
D_ck	***	Dummy of custom kitchen	Equal to 1, if the custom kitchen is equipped and 0, otherwise
D_wm	***	Dummy of the space for the washing machine	Equal to 1, if the space for the washing machine inside the property is available and 0, otherwise
D_bd	***	Dummy of the bath and the dryer	Equal to 1, if the property has a bath and dryer and 0, otherwise
D_br	***	Dummy of the bath and restroom	Equal to 1, if the bath and restroom are not in the same room, and 0, otherwise
D_tg	***	Dummy of terrace or garden	Equal to 1, if the property has a terrace or garden and 0, otherwise
D_ac	***	Dummy of air conditioner	Equal to 1, if the property has air conditioners and 0, otherwise
D_sl	***	Dummy of self-locking system	Equal to 1, if the self-locking system is introduced and 0, otherwise
D_tew	***	Dummy of tiled external wall	Equal to 1, if the external wall of the property is tiled and 0, otherwise

We cannot observe such probability directly, although difference in the subjective probability of an accident due to different distance from the facilities affects the perceived willingness to pay, accounting for chemical risk at various distances. However, by using RISKC05, RISKC10, RISKC15 and RISKC40 in the equation, the estimated parameters reflect differences in perceived willingness to pay based on information about the probability of an accident. These terms indicate a kind of gravity measure, as they include distance but also adjust for carcinogenicity.

We used initial release and transfer data for individual chemical substances that were disclosed under PRTRs in this study. The data for each facility, reflecting releases and transfers generated in 2001, were reported to the government from April to June 2002. In December 2002, the government outlined the results in the newspaper and on the homepage of the Ministry of the Environment. As the data were publicly accessible, they might have affected the rent in 2003. The other variables used in the estimations and the definitions are listed in Table 1.

The distance between the closest train station from property *i* and the closer station (Shibuya or Shinjuku) of Japan Railway Tokyo Loop Line, i.e., Dis_Tokyo$_i$, was measured in travel time, i.e., in minutes, and estimated using the software *Ekispaato* developed by Val Laboratory Corporation [http://www.val.co.jp/ (in Japanese)]. The area served by the Japan Railway Tokyo Loop Line is the central business area in the Tokyo metropolitan area. Shinjuku and Shibuya are the gateway stations for people living in Machida.

Information on other variables about the rental property in December 2003, such as the monthly rent and characteristics of the property, were obtained from RECRUITE Co., Ltd [http://www.forrent.jp/ (in Japanese)]. The information from RECRUITE was provided for people looking for rental properties. In our study, we focused on apartments only and excluded solitary houses, terraced houses, and properties for sale because those properties are in a different market and the number of their observations is limited. The number of observations in this study was 1209.

The MapInfo Geographic Information System (GIS) was used to determine the longitude and latitude coordinates of each property. We calculated the distance between each property and facility by using the latitude and longitude coordinates of each address. Table 2 shows the basic sample statistics.

Table 2
Descriptive Statistics (Means and Standard Deviations).

Variable	Mean	Std. Dev.	Minimum	Maximum
P_i	77.3997	26.27361	29	350
RISKC05$_i$	40037.11	51424.64	0	174518.82
RISKC10$_i$	19773.5	40689.01	0	192582.32
RISKC15$_i$	16198.31	32617.64	0	157436.21
RISKC40$_i$	66382.35	56776.29	0	184631.59
Distance$_i$	0.2096	0.646	0.000468	3.47521
Dis_Tokyo$_i$	45.48718	4.99619	42	59
Dis_station$_i$	10.23821	5.66851	1	33
D_bus	0.24979	0.43307	0	1
Dis_ca	3.18014	3.41763	0.004849	11.98986
D_MachidaSt.	0.83044	0.3754	0	1
TFS$_i$	37.56752	16.91962	14.85	152.52
AGE$_i$	92.16129	95.03218	1	427
Floor$_i$	2.933	2.4345	1	12
D_prk	0.66832	0.47101	0	1
D_high	0.58892	0.49223	0	1
D_n	0.002481	0.049772	0	1
D_e	0.07775	0.26789	0	1
D_w	0.040529	0.19728	0	1
D_ne	0.022333	0.14782	0	1
D_nw	0.021505	0.14512	0	1
D_se	0.17535	0.38042	0	1
D_sw	0.33912	0.47361	0	1
D_wd	0.24152	0.42818	0	1
D_st	0.27295	0.44566	0	1

4. Estimation results

The estimation results are reported in Table 3. White's heteroskedasticity corrected standard errors were used in the regressions.

The parameters of variables related to distance, i.e., Dis_Tokyo, Dis_station and Dis_ca, were negative and statistically significant at the 1% level, as expected. This indicates that longer distance decreases the rent because of greater inconvenience and higher transportation costs. The parameters of D_bus (dummy for usage of bus for local transportation) and AGE (age of the property) were negative and statistically significant. These findings also indicate that properties where the residents need to take the bus to go to the nearest station and older properties have lower rent because of inconvenience and lower utility.

D_MachidaSt (dummy of Machida station), TFS$_i$ (total floor space), Floor (floor of the property), D_high (dummy of high-class apartment), D_wm (dummy of the space for the washing machine), D_bd (dummy of the bath and the dryer), D_br (dummy of the bath and restroom), D_ac (dummy of air conditioner) and D_tew (dummy of tiled external wall) were positive and statistically significant, as expected. These indicate that the rent becomes higher if the properties are more convenient and comfortable. The parameters D_w, D_ne, D_nw and D_sw refer to the direction the property faces and were significantly negative. These findings imply that properties facing west, northeast, northwest and southwest are less preferable than south-facing properties for the residents, which is expected. In Japan, people prefer east- and south-facing apartments to west- and north-facing apartments because north-facing apartments do not benefit from sunlight and west-facing apartments become hotter in the afternoon, especially during the summer.

RISKC15 and RISKC40 were not statistically significant. These findings indicate that residents do not perceive risks generated more than 1.0 km, or 0.625 miles, away from their residence because they are far enough away to avoid the risk. RISKC10 was statistically significant and negative. This indicates that increased carcinogenic risk from facilities 0.5–1.0 km from the property reduces the rent. However, RISKC05 was negative but not statistically significant, which is contrary to our expectation. This finding indicates that

Table 3
Estimation results.

Variable	Estimated coefficient	Asymptotic standard error	P value	
Dis_Tokyo$_i$	−13.42	1.99	0.006	***
Dis_station$_i$	−5.86	1.05	0.000	***
D_bus	−7.22	1.20	0.000	***
Dis_ca	−1.89	0.97	0.000	***
D_MachidaSt.	3.85	2.09	0.026	**
TFS$_i$	5.11	1.24	0.000	***
AGE$_i$	−0.42	3.66	0.094	*
Floor$_i$	1.83	1.17	0.025	**
D_prk	−5.24	2.76	0.000	***
D_high	7.78	1.74	0.000	***
D_n	−3.29	1.73	0.286	
D_e	−9.00	3.08	0.469	
D_w	−3.29	1.31	0.040	**
D_ne	−3.88	2.46	0.003	***
D_nw	−4.45	0.95	0.071	*
D_se	−1.15	2.01	0.254	
D_sw	−2.61	1.62	0.017	**
D_wd	1.24	1.25	0.474	
D_st	−0.97	1.90	0.442	
D_pc	−10.32	1.09	0.000	***
D_other	4.86	1.01	0.020	**
D_mi	1.69	12.23	0.539	
D_ck	2.48	1.60	0.191	
D_wm	2.44	1.45	0.012	**
D_bd	6.36	1.47	0.000	***
D_br	5.80	0.82	0.000	***
D_tg	13.82	0.35	0.255	
D_ac	4.53	0.00022	0.000	***
D_sl	2.10	0.00012	0.292	
D_tew	8.05	0.00035	0.028	**
RISKC05$_i$	−0.00011	11.43	0.606	
RISKC10$_i$	−0.000511	2.73	0.000	***
RISKC15$_i$	0.00054	0.25	0.123	
RISKC40$_i$	−109.12	4.87	0.337	
Const	−49.20	20.72	0.018	**
Number of observations: 1209				
Adjusted $R^2 = 0.812$				
F Value = 154.04				

Note: ***, **, and * indicate that the coefficient is significantly different from 0 at 1%, 5%, 10%, respectively.

although there is some trend that chemical risk reduces rent, we cannot statistically confirm it. This is probably because there is a correlation[13] between RISKC05 and the other risk variables, resulting in the generation of a false estimate. In addition, there might be a problem of the non-significativity of environmental variables due to bias in the data sample (see Cameron, 2006).

From the above results, we conclude that chemical risk within 1 km of a property is likely to affect the residents' perceptions. In our study, the distance for which residents perceive the risk is estimated to be less than in the previous studies [for example, Ihlanfeld and Taylor, 2004]. Our results suggest that the risk perception recognized in the previous studies may reflect other externalities in addition to the chemical risk because the risk is measured by the distance.

Using the estimation results and sample means, we calculated how the increase in RISKC10 affects the rent, elasticity of RISKC10 on the rent, average lost rent per property and share of averaged lost rent in averaged rent (%) as follows:

$$\text{elasticity} \equiv \frac{\partial \ln P}{\partial \ln \text{RISK10}} = \frac{1}{P}\frac{\partial P}{\partial \ln \text{RISK10}} = \frac{\gamma_2}{P} = \frac{1}{P}{}^{*}0.511 = 0.0007$$

[13] There was a high correlation between RISKC05 and RISKC10 (0.64 simple correlation). We estimate the model without RISKC10 and find a negative and statistically significant result of RISKC5.

(Average lost rent per property) = $\gamma_2 \ln RISKC10 = 6.218$ (yen)

(% of Average Lost Rent per property) = (Average lost rent per property)/(Average Rent) = 6.22/77399.67 = 0.0803%

From the estimated value of the elasticity, a 1% increase in RISK10 reduced the average rent by 0.0007%, while RISKC10 reduced the rent by 0.0803%[14] on average. We also estimated a model that used a distance variable instead of a risk variable[15] and found the distance variable to be statistically significant. The parameter was 0.004012 with a 99% significance level. By using an estimated parameter and the sample mean of the rent, the elasticity was 0.0055, which is approximately eight times as much as that with risk index specification.[16] This is probably because the distance variable as a proxy for the risk is likely to capture the other externality as well as the toxicity.

5. Conclusions

Information provision policy is becoming an important regulatory frontier. The disclosure of a facility's environmental performance is likely to contribute to a reduction in negative externalities if people use this information to recognize the risks that facilities produce. To test whether residents perceive the risk, we examined the effect of the risk of releases and transfers of chemical substances from close facilities on rental values. We found that residents do not perceive risk generated more than 1.0 km away from their residence and that they seemed to recognize the increase in carcinogenic risk at distances of 0.5–1.0 km. Thus, the distance at which residents perceive the risk from facilities is less than in previous studies. This is probably because the risk perception recognized in the previous studies may reflect other externalities in addition to the chemical risk because the risk is measured by the distance. In summary, we found that the Japanese housing market responds to publicly disclosed information about a facility's chemical risk.

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Appendix A. Construction of carcinogenic risk index

The index is constructed by multiplying the risk factor by the amount of each chemical related to carcinogenic risk. We summarize these numbers together at each distance level to estimate the total risks. A list of carcinogens and the risk factor for each chemical is shown in Table A.

Table A
ist of carcinogens and risk factors.

Carcinogens	Risk factor
Cadmium and its compounds	5
Chromium compounds 6	5
Nickel compounds	5
Dioxins	5
Vinyl chloride	5
1,3 − butadiene	5
Benzene	5
Dioxins	5
Arsenic and its inorganic compounds	5
Cadmium and its compounds	5
Ethylene oxide	5
Dichlorvos, or DDVP	4
Chlorothalonil or TPN	4
Hydrazine (including hydrazine hydrate)	4
Aniline	4
Mercury and its compounds	4
D−D	4
Dichlorvos, or DDVP	4
Acrylonitrile	4
Formaldehyde	4
Epichlorohydrin	4
Chloroform	4
Tetrachloroethene	4
Lead and its compounds	4
Dinitrotoluene	4
Nickel	4
1,2 − epoxypropane	4
Polychlorinated biphenyls	4
Methyl − 1,3 − phenylene = diisocyanate	4
Acetaldehyde	4
3,3′-dichloro − 4,4′ − Jiaminojifenirumetan	4
Dichloromethane	4
Hydroquinone	3
DMTP or methidathion	3
Acrolein	3
Trichlorfon or DEP	2
Diazinon	2
Fenthion or MPP	2
Chlorpyrifos	2
Marathon or malathion	2
Chloropicrin	2
Fenvalerate	2
Soluble copper salts (excluding complex salts)	2
Endosulfan or Benzoepin	2
Fenbutasuzu oxidation	2
Organic copper or copper oxine	2
Soluble zinc compounds	2
Organotin compounds	2
Manganese and its compounds	2
Inorganic cyanide compounds (except complex salts and cyanate)	2
Chromium and chromium compounds	2
Disulfoton or Echiruchiometon	2
Fenthion or MPP	2
Mancozeb or Manzebu	2
Nebu Man	2
Piribuchikarubu	2
Pyridine	2
Trichloroacetaldehyde	2
Hydrogen fluoride and its water-soluble salt	2
Toluene	2

Data Source: The Organization for Research and Communication on Environmental Risks of Chemicals (ORCERC).

[14] The impact of the risk on the rent is a multiplication of (probability of serious accidents resulting in chemical pollution) and (damage caused by the pollution). Damage caused by pollution could be extensive when a serious accident occurs. Therefore, we understand that the resident has an expectation of very low probability, rather than one of low damage cost.

[15] We also estimate the model including both risk variables and distance variable. We obtain the result that both are insignificant. This suggests that risk variables are likely to correlate with distance variable. From this reason, we drop distance variable from the model.

[16] However, the effect is smaller than in previous studies [for example, Ihlanfeld and Taylor, 2004].

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