Spatial Distribution of Disposal Sites:

Empirical Evidence from Japan

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Abstract

This study is an empirical investigation of the location of industrial waste disposal sites in Japan. We found some evidence of spatial concentration of industrial waste disposal sites in area with other waste-related facilities. In addition, we found a higher number of industrial waste disposal sites per capita in municipalities that had not experienced conflict relating to the construction of disposal sites. Our results suggest that companies may decide to locate disposal sites in areas in which other waste related facilities already exist and/or where there is less citizen conflict over their construction. This would explain why there is a spatial concentration of unwanted facilities in some areas.

Keywords: Disposal site; Industrial waste; Spatial econometrics; NIMBY.

JEL Classification Numbers: D72, Q53, R39.

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1 Introduction

Deciding where to locate facilities is of capital importance for firms. For those dealing with waste disposal, such decisions can be extremely complicated. While firms hope to find an optimal location for their operations, waste disposal sites are generally considered unwanted facilities. Nearby residents often oppose the construction of such facilities, and local governments worry about conflict related to NIMBY (not in my back yard) and LULU (locally unwanted land use) issues. These issues raise several questions: How are site locations determined? Are these locations concentrated in municipalities with specific characteristics? To what extent do residents' opinions affect location decisions? Previous empirical studies on the location decisions of firms have tended to focus on geographical endowment, relative price, transport cost, or agglomeration benefits (Wheeler and Mody 1992; Head et al. 1995, Devereux et al. 2007). In cases of unwanted facilities, however, the local community may put pressure on firms and ultimately affect their location decisions. Thus, residents' welfare loss might be a significant factor in the location decisions for waste facilities.

The purpose of this paper is to understand the spatial distribution of unwanted facilities. Using spatial econometric techniques, we investigate the characteristics of communities in Japan that currently host industrial waste disposal sites. We also examine the characteristics of communities in which conflict over the location of disposal sites is likely to occur and examine the impact of conflict and policy on these location decisions.

Previous studies on the location of waste treatment facilities have mainly focused on site selection procedures. Kunreuther and Kleindorfer (1986) proposed a sealed-bid mechanism for eliciting citizens' willingness to accept facilities. Minehart and Neeman (2002) presented a modified second-price auction procedure for choosing a site location. Swallow et al. (1992) proposed a three-phased approach that integrates the technical, economic, and political dimensions related to the landfill-siting process. While these studies relate to the normative aspect of site selection, few studies have investigated the empirical aspect of location decision making for disposal sites or waste-related facilities. One exception is Laurian and Funderburg

(2014), who focused on the location of waste incinerators in France from the viewpoint of environmental justice.

This study contributes to the existing literature in two ways. First, we investigate the concentration of disposal sites empirically. Since it is difficult to identify municipalities that are most likely to accept disposal sites, waste management companies tend to choose specific municipalities with certain characteristics. Japan provides an excellent setting to test this hypothesis because of its high population density and the scarcity of land for refuse disposal. Second, we examine whether conflict with residents affects the location decision. While it is reasonable to expect that conflict reduces the number of disposal sites per capita, it is unclear to what extent this opposition is successful. For example, conflicts may not reduce the number of disposal sites if legal procedures and regulations do not strictly require the agreement of local residents regarding disposal site selection.

The next section describes the process of locating disposal sites for industrial waste in Japan. Section 3 introduces the method used for estimation as well as the study's empirical strategy. Section 4 explains the model specification and data, and Section 5 explains the results of the spatial concentration analysis of disposal sites and conflict. Finally, Section 6 concludes and discusses policy implications.

2 Background and Hypothesis Development

Figure 1 classifies the types of disposal sites in Japan. Even though the annual volume of industrial waste is ten times greater than that of municipal solid waste, Japan has fewer disposal sites for industrial waste (688) than for municipal solid waste (1,185). The available capacity of industrial waste disposal sites is only 15 years because of the difficulty of siting.

Figure 2 shows the locations of the industrial waste disposal sites currently in operation in Japan. Most disposal sites for industrial waste are constructed and operated by private waste management companies. While these sites are distributed throughout the country, there are particularly high concentrations in some areas, and 82 percent of Japanese municipalities have no industrial disposal sites at all.

What is the mechanism behind the locational concentration of disposal sites? As the economy expands and demand for waste disposal grows, suitable space for disposal becomes scarce. The shortage of disposal sites leads to longer transport distances for waste as well as illegal dumping. This increases anxiety and concern among residents over the construction of disposal sites and waste-related facilities. Although such anxiety and concerns can be mitigated by tighter regulations on the management of disposal sites, such regulations may increase the cost of construction and lead to a further shortage of disposal sites, creating a vicious cycle. Therefore, waste management companies have limited possibilities for new site locations, and they tend to choose areas with existing disposal sites instead of developing new areas. Our first hypothesis can be summarized as follows.

> **Hypothesis 1:** *Waste management companies tend to locate disposal sites in areas in which construction is easier—that is, areas with an existing disposal site. Therefore, there are likely to be some areas in which disposal sites and other waste management facilities are spatially concentrated.*

The typical siting process for disposal sites involves five steps: planning, environmental assessment, permission, construction, and operation. At the planning stage, the waste management company chooses candidate locations based on various factors such as the potential waste supply to the location, transportation costs, and fixed costs, including the land price. The Japanese Environmental Impact Assessment Act and the Waste Management and Public Cleansing Act require constructors of disposal sites to conduct environmental assessments of air, water, and soil pollution. The waste management company must submit an environmental assessment report when applying prefectural permission to construct the disposal site. Permission is granted only if conditions relating to the disposal method and facility equipment standards are met. Although the agreement of nearby residents is not required in a strict legal sense, there are many cases in which opposition by residents has impeded the construction process. Therefore, companies try to obtain the agreement of residents prior to construction, which can lead to significant delays to official operation of the sites. Figure 3 shows an example of a location process with no opposition from residents. Even in such a case, it takes 12 years from the planning stage to operation.

Residents oppose the construction of industrial waste disposal sites for four main reasons. The first is the risk of environmental pollution. Inhabitants of an area that uses a significant amount of groundwater or is prone to landslides may be more anxious about the risks of pollution from disposal sites. Residents may also be anxious about future environmental pollution since there have been several cases in which environmental contamination was discovered after the closure of a site (e.g., Love Canal in New York, USA). The second reason is the economic effects of waste disposal sites on land and housing prices (Kiel and McClain 1995; Farber 1998; McCluskey and Rausser 2003; Ihlanfeldt and Taylor 2004). Proximity to unwanted facilities decreases property values even though such facilities often bring offsetting employment opportunities. In many cases, the devaluation due to nearby changes in land use is an uninsured risk of homeownership (Fischel 2001). The third reason is distrust of waste management companies and local governments. Even when the required environmental assessment has been completed, some residents are suspicious of the results and of the information provided by the companies and government, and they doubt the safety of the waste being disposed of or the disposal methods being employed. Public participation in the siting process should be an important component of information disclosure (Ishizaka and Tanaka 2003; Hsu 2006), as this participatory approach may improve residents' opinions regarding the necessity of the facility, thereby increasing the possibility of acceptance (Lober and Green 1994). The fourth reason is a feeling of unfairness at having to treat waste generated by other communities. The idea of accepting waste from other municipalities often brings antipathy from local residents (Ferreira and Gallagher 2010). To mitigate such antipathy, a fair siting procedure is important in increasing residents' willingness to host a noxious facility (Frey and Oberholzer-Gee 1996).

According to Taguchi (2003), 278 Japanese municipalities experienced protests by residents against the construction of industrial waste disposal sites between 1990 and 2000.[1] Inhabitants opposed construction plans by collecting signatures and submitting petitions to their municipality and prefecture to prevent construction approval. In addition, residents participated in public demonstrations against the waste management companies. As part of such opposition, inhabitants can file lawsuits against the waste management companies; however, the companies can sue the residents as well as the prefecture over the postponement of construction and operation. In many cases, the court recommends that both parties accept a reconciliation plan. This line of reasoning suggests the next hypothesis.

> **Hypothesis 2:** *Residents worry about environmental or economic damage from disposal site, and strongly oppose to the construction of disposal sites. Therefore, the conflict likely to be caused in area where is susceptible to environmental or economic damage from disposal site.*

Even if residential opposition is strong, the prefecture must approve the construction as long as the company's application fulfills all the legal conditions. This means that a waste management company has the right to construct its facility as long as it meets the licensing standards. There have been some cases in which the waste disposal company received approval despite significant local opposition. For example, in the town of Umikami in Chiba Prefecture, a waste facility was built even though 97.6 percent of voters opposed the construction of the site in a local referendum in 1998. While this case suggests that the effect of such conflict might not be strong enough to change the construction plan, a waste management company might wish to avoid a municipality that had already experienced conflict as a candidate for the construction of a new site. This leads to the last hypothesis.

> **Hypothesis 3:** *Waste management companies tend to avoid areas in which conflicts with residents over construction have taken place. Therefore, the*

[1] Japanese local government is divided into two tiers: prefectural governments and municipalities (cities, towns, and villages). The nation comprises 47 prefectures. The number of municipalities was 1,718 in total as of April 2015.

more conflicts over waste facilities there have been in an area, the less likely it is for disposal sites to be constructed there.

3 Spatial Dependency in Disposal Site Location

To test our hypothesis 1, we firstly estimate the Moran's I statistic which is a measure used to test spatial dependency (Anselin 1988). For industrial waste disposal sites, Moran's I is 0.122, with a P value of 0.000. This suggests that spatial dependency exists within the site location data at the 1% level of statistical significance. We also tested spatial dependence among intermediate waste processing facilities as well as among hazardous waste facilities. For the intermediate waste processing facilities, Moran's I is 0.073 with a P value of 0.000, while for hazardous waste facilities, Moran's I is -0.001 with a P value of 0.051. These results show that industrial waste disposal sites have the highest spatial dependency among the waste management facilities. In addition, we examined spatial dependency with regard to citizen conflicts over the construction of industrial waste disposal sites between 1990 and 2000 as reviewed by Taguchi (2003).[2] We found that spatial dependency exists within the conflict data, as Moran's I is 0.109 with a P value of 0.000. Considering these results, aspatial statistical modeling approaches lead to significant model misspecification and biased parameter estimates (Anselin 1988). To detect local patterns of spatial association, we calculated the Anselin local Moran's I statistic (Anselin 1995) and the Getis-Ord Gi* statistic (Getis and Ord 1992; Ord and Getis 1995). The specific test results and a description of the clusters are presented in the Figures 4 and 5.

We estimate a spatial Tobit model to investigate the location of disposal sites and a spatial probit model to investigate the characteristics of communities in which conflict over the location of sites is likely to occur, respectively. The data are for 1,693 municipalities in

[2]The data on conflict related to construction plan of disposal sites is not readily available. For instance, according to the report of the Japanese Ministry of the Environment (1996), there were 221 conflicts related to waste disposal sites between 1990 and 1996. However, the data are at the country level rather than the municipality level, and it is not possible distinguish conflicts over plans for industrial waste disposal sites from those over the operation of such sites.

Japan that share a border with at least one other municipality. A spatial Tobit model is defined as follows:

$$y_i = \begin{cases} y_i^* & \text{if } y_i^* \geq 0 \\ 0 & \text{if } y_i^* < 0, \end{cases}$$

$$y_i^* = (\mathbf{I}_n - \rho\mathbf{W})^{-1}\mathbf{X}\beta + (\mathbf{I}_n - \rho\mathbf{W})^{-1}\epsilon,$$

where y_i^* is the number of disposal sites for industrial waste per 10,000 residents in municipality i, which takes a value of zero if there is no disposal site in the municipality; $\mathbf{X}$ is a vector of characteristics describing the site; $\mathbf{W}$ is spatial weight matrix; and β and ρ are parameters. The negative values from vector y_i^* is set to zero to reflect sample truncation at zero. The spatial weight matrix $\mathbf{W}$ is generated using randomly located coordinates based on each municipality's five nearest neighbors. The conditional distribution for the latent variable thus takes the following form:

$$\begin{aligned} & y_i^* \sim TMVN(\mu, \Omega), \\ & \text{s.t. } \mu = (\mathbf{I}_n - \rho\mathbf{W})^{-1}\mathbf{X}\beta, \\ & \text{and } \Omega = [(\mathbf{I}_n - \rho\mathbf{W})(\mathbf{I}_n - \rho\mathbf{W})]^{-1}. \end{aligned}$$

To estimate the spatial Tobit model, we rely on the Bayesian strategy of the Markov chain Monte Carlo (MCMC) sampling method (LeSage 1999, 2000; LeSage and Pace 2009). The parameters specified are estimated using the Gibbs sampling method based on 1,000 retained draws from a sample of 1,100.

In the spatial probit model, y_i is the binary dependent variable for municipality i. If there is any conflict over the industrial waste disposal site in the municipality, the dependent variable takes a value of one, and if there is no conflict, it takes a value of zero. The model is represented by:

$$y_i = \begin{cases} 1 & \text{if } y_i^* \geq 0 \\ 0 & \text{if } y_i^* < 0, \end{cases}$$

$$y_i^* = (\mathbf{I}_n - \rho\mathbf{W})^{-1}\mathbf{X}\beta + (\mathbf{I}_n - \rho\mathbf{W})^{-1}\epsilon.$$

4 Explanatory Variables

A disposal site requires a considerable amount of land, and in many cases, it is difficult to redevelop such sites after the completion of operation. This suggests that location decisions regarding disposal sites may be more complex than those for other NIMBY and LULU facilities. We hypothesize that five groups of variables can influence the location of disposal sites: conflicts, the existence of other waste-related facilities, local community characteristics, geography, and input markets. The summary statistics for all the variables are presented in Table 1.

As discussed in Section 2, there are many cases in which local residents have campaigned against the construction of a disposal site. It is reasonable to assume that the existence of conflict reduces the number of disposal sites per capita within a municipality. The dummy variable for conflict takes a value of one when there has been any conflict regarding an industrial waste disposal site within a municipality and a value of zero when there has not been any conflict. We use this variable to examine the influence of conflict on disposal site location decisions. We also analyze the characteristics of local municipalities that have had more incidences of conflict over the construction of disposal sites in order to investigate the conditions that may determine residents' acceptance of location planning. The data related to conflicts are drawn from a survey by Taguchi (2003). On the basis of a study of articles published in Japanese newspapers, he identifies 1,218 conflicts over plans for and the operation of waste disposal sites as well as illegal dumping in Japanese municipalities between 1990 and 2000. We use the data for 220 of these conflicts that are related to plans for constructing industrial waste disposal sites. Other conflicts, such as conflicts over the operation of waste disposal sites and waste incineration sites, plans for the construction of municipal solid waste disposal sites, and illegal dumping, are not included in our sample.

To measure the impact of other waste-related facilities, three variables are employed: the number of intermediate processing facilities for industrial waste per capita, the number of disposal sites for hazardous waste per capita, and a dummy variable of disposal sites for industrial waste with public sector involvement. Intermediate processing facilities and hazardous waste facilities are also unwanted land uses. Intermediate waste processing facilities include incineration plants, recycling plants, crushing plants, and separation plants for industrial waste. This variable could also be interpreted as access to input markets since their output is, ultimately, waste that requires final disposal. Hazardous waste facilities accept oil, acid, alkali, infectious waste, polychlorinated biphenyls (PCBs), and asbestos, so it is difficult for a waste management company to find a suitable disposal site location for such a facility since there might be even stronger opposition from residents than for an industrial waste facility. It is expected that the higher the number of other waste-related facilities there are per capita, the higher the number of industrial waste disposal sites there will be per capita. The location data for disposal sites for industrial waste, intermediate processing facilities, and hazardous waste facilities are derived from the 2012 Geographic Information Systems (GIS) database of the Geospatial Information Authority of Japan (2014).

In contrast to the above two variables for waste-related facilities, the existence of industrial waste disposal sites founded with public sector involvement is expected to reduce the concentration of industrial waste disposal sites managed by private company within a municipality. To facilitate the disposal of waste, some prefectures play an active role in the construction of disposal sites for industrial waste. The main reason for this involvement is to reduce possible resident objections that may arise out of anxiety that the public interest may not be an upheld by a private company in pursuit of economic profit. We expect that disposal sites founded with public sector involvement are substitutes for private disposal sites and lead to a lower number of disposal sites by private companies in a municipality. The location data for the publicly supported industrial waste disposal sites are taken from the Survey Report on Administrative Organizations for Industrial Waste by Japanese Ministry of the Environment (2013).

Local community characteristics include variables such as the land price, unemployment rate, population density, percentages of agricultural and manufacturing workers, municipal financial stability index, and city dummy. Land price is a significant part of the fixed cost for the waste management company. We use the average land price in each municipality, which is reported in the Annual Survey of Price Guidelines for Property Values by the Japanese Land Appraisal Committee. The data are drawn from the 2014 Land Price Guidelines on the website of the Land Information Center[3] and the investigation of land prices within each prefecture. The unemployment rate captures the community's political power. By using the unemployment variable, we can test the hypothesis that industrial waste disposal sites might be spatially concentrated in municipalities with more disadvantaged populations. High population density means that there are potentially many inhabitants who would oppose the construction of a site. Agricultural workers might fear that the disposal site will leak pollutants and damage their produce. Conversely, a higher ratio of manufacturing workers and a high municipal financial stability index value indicate greater economic activity, and a municipality that has such characteristics is more likely to support the location decision. We use the city dummy variable to test whether the industrial waste disposal site is located in a rural area[4]. The unemployment, population density, percentages of agricultural and manufacturing workers, and city dummy data are drawn from the 2010 National Census (Japanese Ministry of Internal Affairs and Communications 2010). The municipal financial stability index is drawn from the financial indicators of local governments for 2012 (Japanese

[3] `http://www.lic.or.jp/landinfo/` (Accessed March 16, 2015)

[4] In Japan, a city is defined as a local municipality with more than 50,000 inhabitants, 60% or more of which live in a central area.

Ministry of Internal Affairs and Communications 2012).

The geographic factor is also important in the location decision of a disposal site. To begin construction, companies are required to follow environmental assessment procedures. Among the various aspects that are investigated during this process, we include three representative variables as factors that might strongly affect the location of disposal sites: (1) the number of landslide hazard spots at the prefecture level, (2) the prefectural nature reserve dummy (1 = the disposal site is located in a prefectural nature conservation area, 0 = other), and (3) the amount of groundwater usage at the prefecture level. By including these variables, we can examine whether the location decision is influenced by consideration of disaster risk aversion and the natural environment. The data regarding the number of landslide hazard spots are drawn from the website of the Japanese Ministry of Land, Infrastructure, Transport and Tourism.[5] The data for nature reserves are based on prefectural nature conservation areas as of 2014. Under the Japanese Nature Conservation Law, areas for nature conservation are classified as wilderness areas, nature conservation areas, and prefectural nature conservation areas. The prefectural nature conservation areas are designated by the prefectural governments, and the regulations on land use in such areas are less strict than for the other two types. The data regarding groundwater usage are drawn from the Fifth Survey on the Usage of Groundwater for Agriculture (Japanese Ministry of Agriculture, and Fisheries 2011).

The last group of explanatory variables is input markets. Empirical studies suggest that input markets have a significant effect on plant location (Fortenbery et al. 2013). In the case of industrial waste, the input for disposal sites is the waste generated by industrial activities. This study uses three variables for the input markets: (1) the amount of industrial waste generated at the prefectural level, (2) the revenue from production by the local manufacturing sector measured at the municipal level, and (3) the total length of highway infrastructure measured at the prefectural level. The generation of industrial waste captures the supply

[5] `http://www.mlit.go.jp/river/sabo/link20.htm` (Accessed March 16, 2015)

of waste processed for disposal within the prefecture.[6] The total revenue of production by the local manufacturing sector captures the demand for waste disposal in the municipality. The total length of the municipality's highways reflects the amount of transportation infrastructure, and a greater length should be associated with lower transportation costs. Data on industrial waste generation are drawn from the 2012 Survey on Industrial Waste Emissions and Disposal (Japanese Ministry of the Environment 2012). The data regarding manufacturing production are drawn from the 2012 census of manufacturers (Japanese Ministry of Economy, Trade and Industry 2012). The data regarding the total length of highway infrastructure in each municipality are drawn from the Annual Report of Road Statistics 2010 (Japanese Ministry of Land, Infrastructure, Transport and Tourism 2010).

5 Results

5.1 Spatial Concentration of Disposal Sites

We estimate models that take the number of industrial waste disposal sites per capita as the dependent variable. There is a high correlation between the amount of industrial waste output variable and the length of highway infrastructure variable, so we do not include them in the same model. The results of the Bayesian spatial Tobit models and spatial probit models are presented in Table 2. For completeness, we also report the estimation results by the aspatial Tobit and probit models. The spatial parameter ρ is statistically significant in the four models estimated using spatial methods. The results show that the disposal sites for industrial waste are spatially concentrated. Thus, we found strong support for our first hypothesis, in addition to the result of Moran's I statistics.

The results in Table 2 indicate that the number of intermediate processing facilities for industrial waste per capita and the number of hazardous waste disposal sites per capita have positive and statistically significant coefficients. A higher number of these waste-related

[6]The data on the amount of industrial waste generated at municipality level is unavailable.

facilities is associated with a higher number of industrial waste disposal sites. This result suggests that waste management companies may find a suitable place for construction in municipalities that have a higher number of other waste-related facilities per capita.

Contrary to our expectations, the location of publicly supported disposal sites is positively associated with the number of disposal sites per capita. The public site variable in Table 2 has positive and significant coefficients, which means that the private disposal sites per residents is higher in municipalities that have publicly supported disposal sites. If the construction of a public site increases the acceptability of waste facilities in general, it might also encourage the construction of private disposal sites as well, similar to the effect of other waste-related facilities.

Land price and population density are statistically significant and negative. These results are plausible, since higher land price and higher population density means higher costs of locating disposal sites. Unemployment is positive but not statistically significant. The result is in contrast to that of Laurian and Funderburg (2014), who found that towns in France with large vulnerable populations are more likely to host the construction of waste incineration facilities. The percentage of agricultural workers is positive but not statistically significant, while the percentage of manufacturing workers is negative and has statistically significant coefficients. The city dummy is statistically significant with positive coefficients, although this result might come from either stronger demand for disposal of waste or from significance of the transportation costs of waste.

Among the three geographical variables, only the level of groundwater usage is statistically significant with negative coefficients. This suggests that the municipalities with higher levels of groundwater usage are less likely locations for disposal sites. Since higher dependence to groundwater means higher possibility of pollution damage, the negative coefficient of the variable is in line with our expectation.

Input market factors are highly significant in every specifications. The amount of industrial waste and total revenue from manufacturing production are positive and significant.

These results suggest that the location of industrial waste disposal sites is sensitive to the market where waste for disposal is generated. The total length of highway infrastructure within a municipality is statistically significant and positive, suggesting an important role that the level of infrastructure for transportation might play in determining the locations of disposal sites.

5.2 Spatial Concentration of Conflicts

Next, we investigate a model that explains the number of conflicts per capita to test our hypothesis 2. We use as a dependent variable a dummy variable that takes a value of one if a municipality had a conflict over the construction of an industrial waste disposal site between 1990 and 2000. The explanatory variables in this model are similar to those used in the models for the location of disposal sites, except with the data period being 2000 instead of 2012. Since the data of landslide hazard spots and groundwater usages are not available for the year 2000, we use the data for the years 2002 and 1996, respectively.

The estimation results from the spatial probit model are presented in Table 3. The coefficients of unemployment are negative and statistically significant in model 2-2 and model 2-4. This is in contrast to the result shown in Table 2 that unemployment has positive and statistically insignificant coefficients on location of disposal sites. These results suggest that a municipality with high unemployment has a lower potential for conflict, although this might not be associated with a significant increase in the number of disposal sites. The city dummy is positive and statistically significant, which can be interpreted as that residents living in urban areas tend to oppose the construction of disposal sites. The agricultural worker and manufacturing worker variables are positive but not statistically significant.

The number of landslide hazard spots and the amount of groundwater usage are positive and significant. These results supports our hypothesis 2 that inhabitants in municipalities with vulnerable environment are more likely to worry about environmental damage and to strongly oppose to the construction of disposal sites.

The variable for the amount of industrial waste is negative and statistically significant. Higher industrial waste generation in a municipality is associated with a lower potential for conflict over disposal sites. To put different way, conflict is higher where industrial waste generation is lower. This is in line with the result by Ferreira and Gallagher (2010) that the treatment of local waste at a local facility is important driver for mitigating the protest response toward accepting compensation to host waste disposal facility.

5.3 Impact of Conflict on the Concentration of Disposal Sites

To test our hypothesis 3 on the impact of conflict on the location of disposal sites for industrial waste, we cannot simply include the conflict variable in a regression model of the location decision making. Since conflicts take place only when there is a plan for a disposal site, conflict might positively correlate with location, although this does not necessarily mean that conflict increases disposal site concentration. Therefore, the analysis in this section restricts the sample to municipalities that had any construction plans for a disposal site.

Since an official list of construction plans for industrial waste disposal sites is not available, we constructed the sample as follows. If a municipality had a completed disposal site, it means there was a plan to build it. If a municipality had a conflict case, it also means there was a plan to build a disposal site. We combine these two sets of municipalities and assume these are the municipalities with construction plans. Although this procedure omits municipalities that had plans for disposal sites that were never completed while never experienced conflict, it is probably reasonable to think that such cases are few.

Conflict is measured by a dummy variable that takes a value of one if a municipality had more than one conflict over the construction of disposal sites. We use 220 municipality-level conflicts over plans for the construction of industrial waste disposal sites between 1990 and 2000 (Taguchi 2003). While the data are conflict between 1990 and 2000, location data are as of 2012. It is probable that the sites in operation in 2012 were built before 2000 since the typical operation length of disposal sites is longer than 15 years. Thus, we consider that conflicts between 1990 and 2000 had some impact on the location decisions of the disposal sites that were in operation in 2012. We expect that conflict is negatively related to site location for two reasons: (1) the transaction costs become higher for waste management companies to negotiate with inhabitants, and (2) the opportunity costs also become higher as the construction and operation of the site is delayed.

The estimation results from the Tobit model are presented in Table 4. The conflict dummy is negative and statistically significant, which means that the construction of disposal sites per capita is higher in a municipality that has experienced conflict with inhabitants. This finding supports our third hypothesis that conflict with inhabitants can decrease the possibility of site location because of higher transaction costs and opportunity costs for waste management companies. The results regarding to other independent variables are quite similar to the estimation results shown in Table 2.

6 Conclusions

This study investigated the relationship between the location of disposal sites and the characteristics of local communities. We found that disposal sites for industrial waste were concentrated in particular area. In addition, we focused on conflict with residents over the construction of these sites and analyzed the factors related to the occurrence of conflict as well as the impact of conflict on site location.

Our results revealed the characteristics of areas in Japan in which industrial waste disposal sites are spatially concentrated. The results showed that the existence of other waste-related facilities is associated with a higher number of disposal sites for industrial waste per capita. While the significance of groundwater usage suggests the importance of environmental factors in location decision making, input market factors such as the amount of industrial waste and highway length also played significant roles.

We further analyzed the impact of conflict on the location decisions. The results show that the occurrence of conflict has a negative relationship with location decisions, which suggests that waste management companies tend to avoid municipalities with a high probability of conflict despite the fact that these companies have the legal right to construct their sites.

The results of this study have important implications for environmental policy. Firstly, concentration of waste-related facilities suggest that the environmental impact of waste-related facilities can be extremely high in these areas. Secondly, while the existence of conflict in a given municipality might reduce the number of industrial waste disposal sites per capita, it might also result in a shift in the site location to another municipality. In that sense, the concentration of disposal sites in some areas might be attributable to the weak bargaining power of certain local communities. Thirdly, if residents want to avoid the construction of local disposal sites and other waste-related facilities, it is important for them to reduce the generation of waste within their municipality. However, it is not easy for a single municipality to implement a practical intervention to reduce the volume of industrial waste. Waste disposal sites are often unwanted by the local communities in which they operate, while it is inevitably important service for society as a whole. It is thus important to understand how to mitigate the concentration of these sites and conflict over their construction.

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Table 1: Descriptive statistics

	Unit	Mean	Min	Max	SD
Disposal site for industrial waste	sites/10,000 persons	0.125	0	6.485	0.496
Disposal site for hazardous waste	sites/10,000 persons	0.068	0	15.038	0.474
Intermediate site for industrial waste	sites/10,000 persons	1.306	0	64.088	2.264
Publicly supported disposal site	1 = yes, 0 = otherwise	0.027	0	1	0.163
Land price	10,000 yen	6.111	0.162	546.7	22.711
Unemployment	%	6.327	0	22.718	2.123
Population density	1,000 persons/km^2	4.127	0.001	218.815	18.701
Agricultural workers	%	4.94	0	52.333	5.187
Manufacturing workers	%	8.131	0.492	23.831	4.094
Municipal financial stability index	points	0.5	0.07	2.13	0.282
City	1= yes, 0= otherwise	0.461	0	1	0.499
Number of landslide	1,000 spots	22.025	2.064	63.974	11.241
Nature reserve	1 = yes, 0 = otherwise	0.203	0	1	0.402
Amount of groundwater usage	million m^3	6.219	0.21	69.087	10.204
Total manufacturing revenue	billion yen	17.013	0	1208.886	48.038
Amount of industrial waste	10 million ton	1.178	0.123	3.576	1.017
Length of highway infrastructure	km	266.661	18.2	894.4	236.344
Conflict	1 = yes, 0 = otherwise	0.129	0	1	0.336

Table 2: Determinants of locations for industrial waste disposal site

	Spatial Tobit		**Aspatial Tobit**	
	Model 1-1	Model 1-2	Model 1-3	Model 1-4
Disposal site for hazardous waste	0.329***	0.329***	0.306***	0.308***
	(0.010)	(0.096)	(0.085)	(0.083)
Intermediate site for industrial waste	0.111***	0.105***	0.099***	0.096***
	(0.025)	(0.021)	(0.020)	(0.020)
Publicly supported disposal site	0.534*	0.456*	0.481*	0.411*
	(0.296)	(0.268)	(0.253)	(0.249)
Land price	−0.068***	−0.054***	−0.071***	−0.051***
	(0.014)	(0.012)	(0.017)	(0.016)
Population density	−0.028*	−0.032**	−0.036*	−0.029
	(0.015)	(0.014)	(0.020)	(0.019)
Unemployment	0.020	0.042	0.023	0.041
	(0.028)	(0.028)	(0.026)	(0.026)
Agricultural workers	0.018	0.017	0.018	0.019
	(0.016)	(0.015)	(0.013)	(0.013)
Manufacturing workers	−0.027*	−0.027*	−0.020	−0.021
	(0.016)	(0.016)	(0.015)	(0.014)
Municipal financial stability index	0.035	0.275	0.061	0.250
	(0.293)	(0.306)	(0.279)	(0.272)
City	0.989***	0.907***	0.759***	0.770***
	(0.178)	(0.151)	(0.142)	(0.140)
Number of landslides	0.000	−0.001	0.001	−0.001
	(0.005)	(0.005)	(0.005)	(0.005)
Nature reserve	0.036	−0.001	0.009	−0.010
	(0.134)	(0.137)	(0.121)	(0.120)
Amount of groundwater usage	−0.025***	−0.020***	−0.027***	−0.021***
	(0.007)	(0.007)	(0.008)	(0.007)
Total manufacturing revenue	0.004***	0.004***	0.003***	0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Amount of industrial waste	0.266***		0.312***	
	(0.052)		(0.047)	
Length of highway infrastructure		0.002***		0.002***
		(0.000)		(0.000)
ρ	0.221***	0.195***		
	(0.051)	(0.055)		
σ^2	2.378***	2.172***		
	(0.306)	(0.237)		
Intercept	−1.925***	−2.252***	−1.946***	−2.338***
	(0.420)	(0.424)	(0.372)	(0.383)
Observations	1,693	1,693	1,693	1,693

Note: Standard errors are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Determinants of conflict over the construction plan for disposal site

	Spatial Tobit		**Aspatial Tobit**	
	Model 2-1	Model 2-2	Model 2-3	Model 2-4
Disposal site for hazardous waste	4.572	−9.183	5.170	−13.250**
	(5.278)	(5.709)	(6.151)	(6.530)
Intermediate site for industrial waste	−0.080	−0.036	−0.063	−0.012
	(0.066)	(0.067)	(0.076)	(0.073)
Publicly supported disposal site	0.229	0.239	0.277	0.273
	(0.247)	(0.262)	(0.245)	(0.247)
Land price	−0.007	−0.006	−0.001	−0.001
	(0.009)	(0.007)	(0.008)	(0.007)
Population density	−0.144**	−0.139**	−0.208***	−0.017
	(0.058)	(0.057)	(0.062)	(0.012)
Unemployment	−0.014	−0.016*	−0.014	−0.207***
	(0.012)	(0.009)	(0.012)	(0.060)
Agricultural workers	0.005	0.005	0.006	0.005
	(0.009)	(0.009)	(0.010)	(0.010)
Manufacturing workers	0.006	0.005	0.009	0.007
	(0.009)	(0.009)	(0.010)	(0.010)
Municipal financial stability index	0.008	−0.085	0.045	−0.072
	(0.199)	(0.200)	(0.218)	(0.220)
City	0.681***	0.677***	0.671***	0.675***
	(0.096)	(0.092)	(0.094)	(0.094)
Number of landslides	0.012*	0.011*	0.018**	0.015**
	(0.006)	(0.006)	(0.007)	(0.008)
Nature reserve	0.036	0.027	0.017	−0.007
	(0.100)	(0.104)	(0.101)	(0.102)
Amount of groundwater usage	0.005*	0.007**	0.006*	0.009***
	(0.003)	(0.003)	(0.003)	(0.003)
Total manufacturing revenue	−0.001	−0.001	−0.001	−0.001
	(0.001)	(0.002)	(0.001)	(0.002)
Amount of industrial waste	−0.011**		−0.014**	
	(0.005)		(0.006)	
Length of highway infrastructure		0.001*		0.001**
		(0.000)		(0.001)
ρ	0.355***	0.351***		
	(0.075)	(0.074)		
Intercept	−0.963***	−1.166***	−1.462***	−1.690***
	(0.225)	(0.214)	(0.233)	(0.226)
Observations	1,693	1,693	1,693	1,693

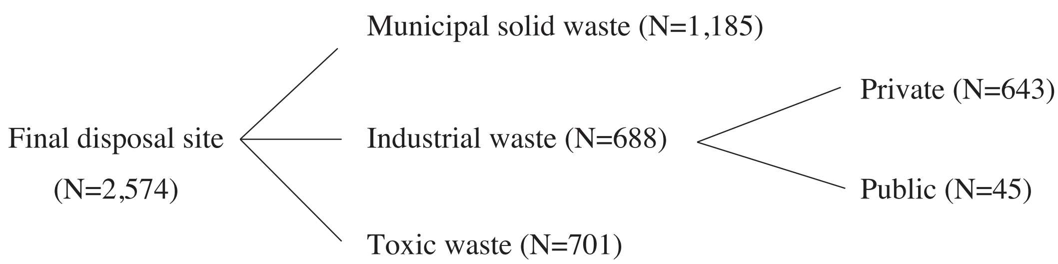
Note: Standard errors are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Impact of conflict on the concentration of disposal sites

	Aspatial Tobit	
	Model 3-1	Model 3-2
Conflict	-0.925^{***}	-0.917^{***}
	(0.089)	(0.089)
Disposal site for hazardous waste	0.207^{***}	0.208^{***}
	(0.056)	(0.056)
Intermediate site for industrial waste	0.032^{**}	0.033^{**}
	(0.014)	(0.013)
Publicly supported disposal site	0.000	-0.032
	(0.170)	(0.169)
Land price	0.006	0.013
	(0.016)	(0.016)
Population density	0.012	0.025
	(0.022)	(0.022)
Unemployment	0.000	0.000
	(0.000)	(0.000)
Agricultural worker	0.040^{***}	0.044^{***}
	(0.013)	(0.013)
Manufacturing worker	-0.008	-0.010
	(0.013)	(0.012)
Municipal financial stability index	-0.545^{**}	-0.404^{*}
	(0.239)	(0.240)
City	-0.290^{**}	-0.268^{**}
	(0.117)	(0.117)
Number of landslides	-0.005	-0.006
	(0.004)	(0.004)
Nature reserve	-0.027	-0.050
	(0.096)	(0.096)
Amount of groundwater usage	-0.013^{**}	-0.011^{**}
	(0.005)	(0.005)
Total manufacturing revenue	0.000	0.000
	(0.001)	(0.001)
Amount of industrial waste	0.210^{***}	
	(0.039)	
Length of highway infrastructure		0.001^{***}
		(0.000)
Intercept	0.756^{**}	0.491
	(0.321)	(0.339)
Observations	462	462

Note: Standard errors are given in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Figure 1: Classification of disposal site in Japan



Source: Japanese Ministry of the Environment (2014), Geospatial Information Authority of Japan (2014)

Figure 2: Locations of industrial waste disposal sites throughout Japan

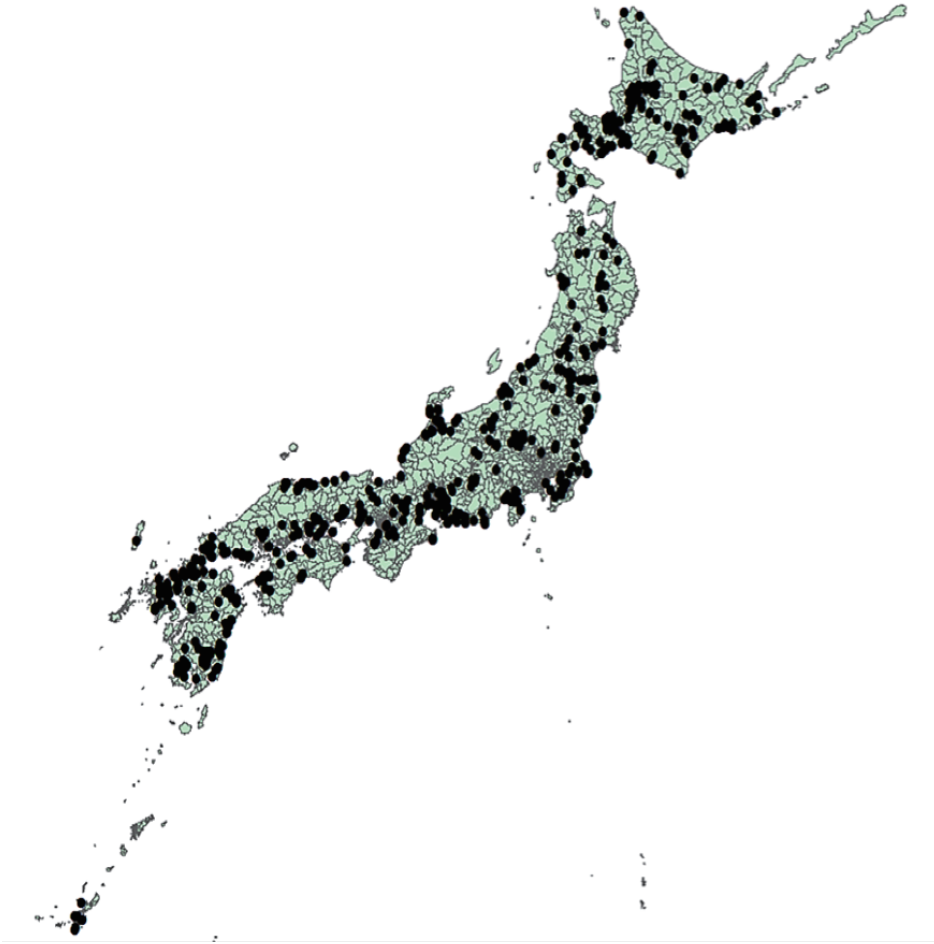
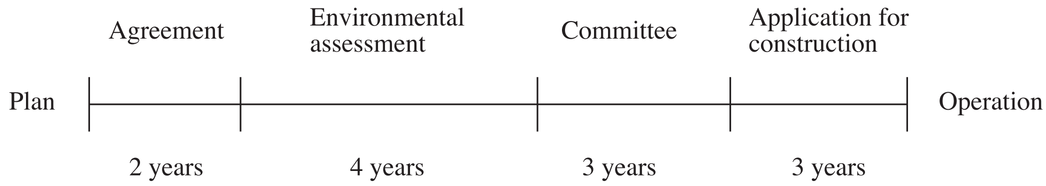


Figure 3: Example of the siting process without conflict



Source: Sugiyama (2012)

Figure 4: Spatial clustering of final disposal sites via the Anselin Local Moran's I

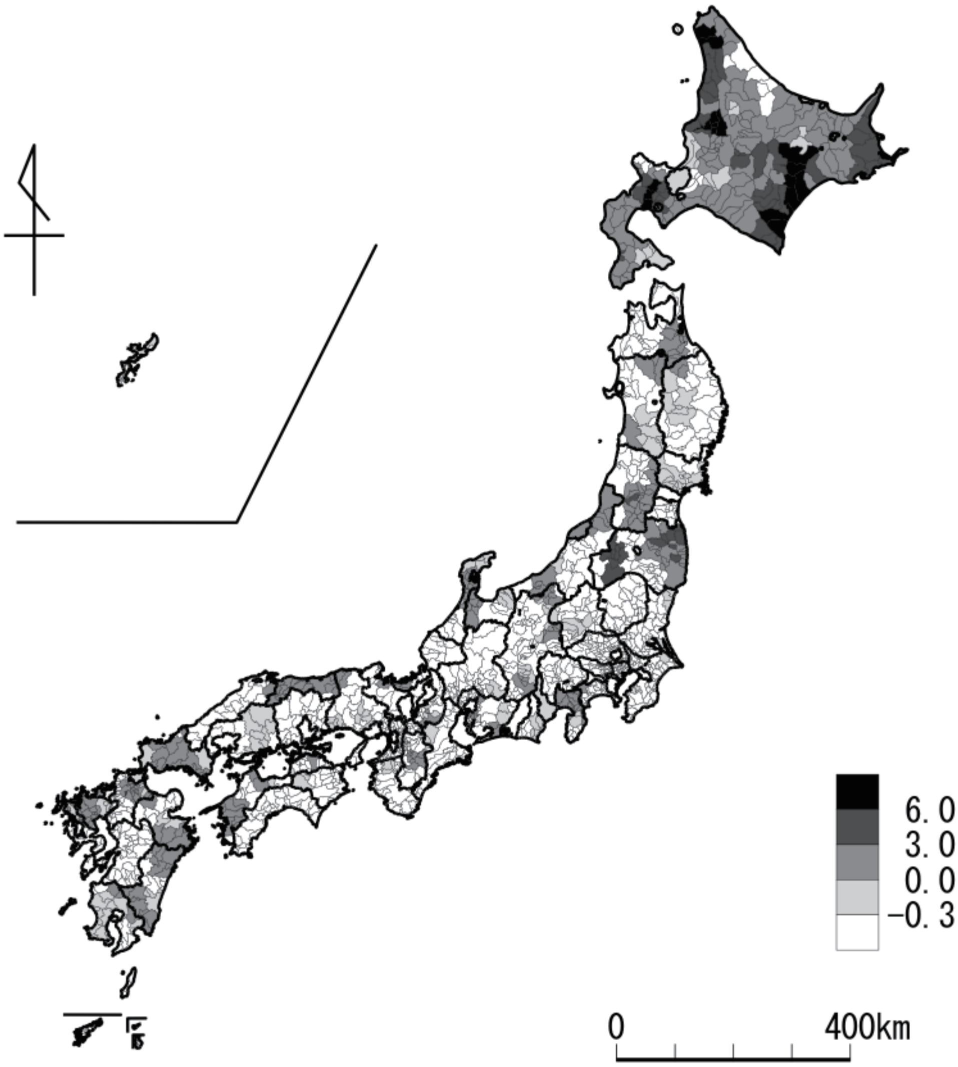


Figure 5: Spatial clustering of final disposal sites via Getis-Ord Gi*