Economics of Waste Management and NIMBY

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（廃棄物政策と NIMBY の経済分析）

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Chapter 1

Introduction

NIMBY (not in my backyard) is a serious political concern that bothers both governments and firms. NIMBY can be defined as follows: “someone who objects to the occurrence of something in their own neighborhood but does not object to it elsewhere”. This phenomenon can be typically seen concerning the location of unwanted facilities in a locality. For example, local communities often refuse unwanted facilities such as waste disposal sites, nuclear power plants, prisons, airports, dams, etc., while understanding the social necessity of these facilities. As long as such facilities are socially necessary, the NIMBY problem remaines a social problem that can not be permanently avoided by government, firms, or residents. Therefore, it is important to understand what complicates NIMBY issues and how conflicts of NIMBY can be mitigated.

The NIMBY issue is particularly serious in the case of waste management and is typically they are related with the efficiency of waste policy. The transfer of waste between regions or the optimal location of a waste disposal site for operation have been discussed from the viewpoint of efficiency. The former is efficiency related to the comparative advantage between regions for waste treatment. The latter is related to the demand for waste disposal as well as the cost of land acquisition and transportation. While waste management pursues efficiency and profit maximization, it does not often enough consider equity, risk, and environmental damage due to policy implementation. When these elements are not considered, then opposition to waste trade and location of disposal site arises.

The main objective of this thesis is to answer the following two questions: “What exacerbates NIMBY?” and “How to mitigate NIMBY?”. Particularly, this study addresses NIMBY problems relating to (1) the wide area treatment of disaster waste, and (2) the locational concentration of waste disposal sites. In the former, we investigate the characteristics of municipalities that responded to requests for accepting disaster waste from the Great East Japan Earthquake, as well as the factors that prevented and promoted the residents agreement for accepting the disaster waste from affected areas. In particular, we focus on the role of social factors such as altruism, measured as the amount of donations to disaster victims, and reciprocity, i.e. whether accepting municipalities themselves face risk of a similar situation. These YIMBY (yes in my backyard) motivations might contribute to a decision to accept disaster waste, even though there is a negative perception relating to the risk of environmental contamination. The contribution of this analysis is to understand the pro-social behavior of residents and community characteristics that would facilitate recovery from future natural disasters.

We also focus on the location of industrial waste disposal sites in Japan and investigate the characteristics of communities that host these sites. We examine the characteristics of communities in which conflict over the location of disposal sites is likely to occur and estimate the impact of conflict and policy on making these location decisions. The results of our analysis may have policy implications for the efficient and equitable management of unwanted facilities.

This thesis is structured as follows. Chapter 2 focuses on the determinants of transfer of disaster waste resulting from the Great East Japan Earthquake between the affected areas and other municipalities. Chapter 3 empirically investigates the location decisions of waste disposal sites. In addition, we analyze the community characteristics where conflict with residents is likely to take place, and the impact of conflict on the location decisions of sites. Chapter 4 empirically examines the changes in location decisions of disposal sites from a long-term perspective using unique data on geographical distribution of industrial waste disposal sites from 1992 to 2012. Chapter 5 concludes and discusses policy implications.

Chapter 2

NIMBY or YIMBY?

Municipalities' reaction to Disaster Waste from the Great East Japan Earthquake

2.1 Introduction

On March 11, 2011, the Great East Japan Earthquake that occurred off the Pacific coast of Japan triggered a massive tsunami. It heavily impacted areas in the three prefectures of Iwate, Miyagi, and Fukushima, resulted in 15,884 fatalities and 2,633 missing persons. The tsunami destroyed many houses and buildings and a huge amount of disaster waste was generated. The tsunami also damaged the Fukushima Daiichi nuclear power plant, leading to a release of radioactive isotopes, and in turn to radioactive waste.

The amounts of waste generated by the tsunami were considerably larger than that of the annual municipal solid waste in these prefectures. The affected prefectures and Japanese Ministry of Environment compiled a plan to remove disaster waste within three years, since huge amount of disaster waste could hamper disaster recovery in affected areas. Therefore, the Japanese Ministry of Environment inquired municipalities about the possibility of accepting the disaster waste from the Iwate and Miyagi prefectures. The disaster waste generated in Fukushima prefecture was not included in the wide area treatment because of the radiation risk. When municipalities were asked about the possibility of acceptance just after the earthquake, 852 municipalities out of 1,592 stated that they could accept disaster waste. Later on, as we will discuss, only 76 municipalities actually accepted disaster waste.

The tragic event of the tsunami provides us with an interesting case of movement of waste between regions/municipalities. There is an empirical literature that has investigated the determinants of the transfer of waste between states and countries. For example, Levinson (1999a, 1999b) investigated the influence of a waste disposal tax on the movement of hazardous waste between states in the United States. It was found that factors such as population size and density, land area, and capacity of the disposal site had a positive impact on the amount of wide area treatment while factors such as the distance between states, and income had a negative impact. Baggs (2009) studied the international transfer of hazardous waste using data collected through the implementation of the Basel Convention. The results suggest that the movement of waste is better explained by the differences in capital per worker than by differences in income per capita. It means that more capital-intensive nations import more hazardous waste for disposal.

The focus of the studies mentioned above has mainly been on the impact of economic factors. While they might be also of importance for disaster waste, it is likely that social factors such as pro-social and anti-social behavior, and reciprocity could play important roles in the time of crisis. Studies in psychology suggest that disasters can invoke both pro-social and anti-social behavior among individuals; see e.g. Gantt and Gantt (2012). Using economic experiments, Becchetti et al. (2012) find that there are long-run negative effects on altruism of being a victim of a natural disaster such as a Tsunami, while Li et al. (2013) find heterogeneous effects depending on the age of the victim. There is also an extensive literature suggest that factors such as fear of objective and subjective risks are important in determining local residents attitudes towards locally undesirable development such as landfills (see e.g. Gallagher et al., 2008; Jenkins et al., 2004; Lober and Green, 1994; McClelland et al., 1990). Residents opposition to development of necessary facilities has given rise to the term NIMBY (Not In My Back Yard). As discussed by Frey et al. (1996), monetary compensation does not in many cases increase the level of support to NIMBY facilities. On the contrary, compensation could crowd-out intrinsic motivation (Frey and Oberholzer-Gee 1997; Titmus, 1970). This also suggests that intrinsic pro-social factors could be important for the attitudes towards these types of projects. There are actually examples of counter-movements; often using the term YIMBY (Yes In My Backyard), that has more positive attitudes towards changes in the built environment.

In this chapter, we investigate the characteristics of the municipalities that responded to the request for accepting the disaster waste of the Great East Japan Earthquake. In particular, we focus on the role of social factors such as altruism, measured as the amount of donations to the disaster victims, and reciprocity, i.e. if accepting municipalities themselves face the risks of similar situation. These YIMBY motivations can contribute to the decision to accept the disaster waste, even though there is a negative perception relating to the risk of environmental contamination.

The next section contains a description of the situation and the request for treatment of disaster waste. Section 2.3 introduces the data and the empirical strategy. Results are presented in Section 2.4 and Section 2.5 presents the conclusion.

2.2 Background

The tsunami that followed the Great East Japan Earthquake resulted in a huge amount of disaster waste. The amount of the disaster waste in Iwate prefecture was about 5.74 million tons, in Miyagi prefecture it was 18.77 million tons, and in Fukushima prefecture it was 3.49 million tons. These are approximately 13 times, 22 times, and 5 times larger than that of the annual municipal solid waste in these prefectures, respectively. Iwate and Miyagi prefectures requested other municipalities to accept wide area treatment of the disaster waste through the Japanese Ministry of Environment. The disaster waste generated in Fukushima prefecture has not been included in the wide area treatment so far because of radiation risk.

The Ministry of Environment inquired municipalities about the possibility of accepting the disaster waste in April 2011. As a result, 42 prefectures and 572 municipalities expressed intentions of accepting the disaster waste.[1] The aggregate capacity of the incinerators in these municipalities amounted to about 2.93 million tons per year, suggesting that the wide area treatment could help a prompt response for disaster recovery. However, when the Ministry of Environment investigated the intentions again in October 2011, there were only 54 municipalities that had already accepted, or began actions towards acceptance. Compared to the investigation results of April 2011, it is clear that negative attitudes among the municipalities had increased.

The main reason was the anxiety over the possibility of radioactive contamination of the waste. In June 2011, it was detected that the radiation level in the incineration ashes of the municipal solid waste in Edogawa Ward in Tokyo was higher than the acceptable level for

[1] Japanese local government is divided into two tiers: prefectural governments and municipalities (cities, towns and villages). The nation consists of 47 prefectures. The number of municipalities is 1,719 in total as of April 2012, including affected area.

disposal stated by the guideline of the Ministry of the Environment.[2] Although the incidence did not relate to the wide area treatment, it invoked an anxiety among Japanese residents that the radioactive contamination might spread over a wider area than reported by government officials and mass media.

This chapter investigates the municipalities' decision on accepting the tsunami waste by using cross-sectional data from 1,592 municipalities that does not include the municipalities of Miyagi, Iwate, and Fukushima prefectures. The data on the acceptance of disaster waste is based on the reports from the municipalities, collected by the Ministry of the Environment as of April 8, 2011, June 26, 2012 and October 25, 2013.[3]

The 2011 and 2012 data on the acceptance status contains the list of municipalities that have been examining the possibility of acceptance, that expressed the intention of acceptance, or that have already accepted the disaster waste. We treat these municipalities as positive towards acceptance. The 2013 data contains a list of municipalities that have already accepted the disaster waste. Table 2.1 shows the number of municipalities that were either positive or negative toward accepting the waste from 2011 to 2013. On June 29, 2012, The Ministry of the Environment informed that there were enough expressed intentions of acceptance from municipalities to treat the existing tsunami waste and there was no need to examine further interest from other municipalities. As of October 2013, 76 municipalities have accepted the tsunami waste. Most of these municipalities are in the eastern part of Japan. Figure 2.1 shows the percentage of municipalities that are positive toward the acceptance of the tsunami waste in each prefecture from 2011 to 2013.

In principle, Japanese administration categorizes disaster waste as municipal solid waste and municipalities are responsible for its treatment. However, the treatment is beyond the capacity of municipalities when the amount of disaster waste is huge. In the case of the Great East Japan Earthquake, there was a significant need for cooperation among the municipalities and coordination by the Ministry of the Environment and prefectural governments. In fact, the Ministry of the Environment actively supported municipalities and played a role of

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[2] According to the guidelines of the Ministry of the Environment, radiation levels of the combustible waste must be less than 240Bq/kg for incineration and that of the incombustible waste must be less than 8,000Bq/kg for final disposal.

[3] Data on the acceptance status in June 2012 and October 2013 was retrieved from the web site of the Ministry of the Environment, while that in April 2011 was obtained through a request for disclosure of information to the Ministry of the Environment based on the Law Concerning Access to Information held by Administrative Organisations.

coordinating the stakeholders in the wide area treatment of the tsunami waste. The Ministry inquired the possibility of acceptance of disaster waste through prefectural governments, facilitated the cooperation between the affected municipalities and the host municipalities, and provided financial assistance for such cooperation. The role of prefectural governments of potential host municipalities was basically modest as that of liaison and coordination. In some prefectures, however, disaster waste was accepted by incineration facilities or waste disposal site that were owned by prefectural government. One example is Tokyo, which accepted about 25,000 tons of tsunami waste from several municipalities.

The decision of acceptance by host municipality typically takes following steps. First, the mayor announces the intention of accepting disaster waste, as well as its amount, type of waste, and the time period. The municipal government tries to obtain the consent of residents nearby the plant and other area. Second, the host municipality runs a small scale experiment of disposal, measures the radiation level of the waste, and announces the results to alleviate residents' anxiety. Finally, the municipality makes a decision to accept disaster waste upon the approval of municipal congress. An affected municipality can receive a subsidy from the Ministry of the Environment to cover the entire cost of implementing the wide area treatment. Thus, the cost of disaster waste treatment is financed by federal budget.

The practice of wide area treatment involves the monitoring of radiation level for several times. Table 2.2 describes the steps of the wide area treatment for the case of Osaka city, which accepted 15,000 tons of combustible disaster waste from the Miyako area in Iwate prefecture. The disposal cost was at least 290 million yen. The tsunami waste contains many materials such as mud, concrete, plants, houses, cars, and various products. At the first temporary site in the Miyako area, the disaster waste was separated into combustibles and incombustibles, hazardous and non-hazardous, and recyclable and non-recyclable (by hand or machine). The separated waste was sent to a second temporary site and further separated by hand. After the separation process, the radiation level of the waste was measured at the second temporary site. The radiation level was measured again before loading it onto ships and trucks for transportation. When the disaster waste arrived at a harbor and a transshipment facility near the accepting municipality, the radiation level was measured again. In the transshipment facility, machines removed hazardous waste and incombustibles found in the disaster waste. Lastly, the disaster waste was treated in an incineration plant and sent to a disposal site. It was disposed together with municipal solid waste after the final measurement of concentration of radioactive material.

2.3 Data and empirical strategy

2.3.1 Factors affecting the acceptance of waste

We include five types of variables in the estimation, namely: variables relating to social preference, economic efficiency, radiation risk, political orientation, and demography. Summary statistics of all the variables are presented in Table 2.3.

Social preference

We include four variables related to social preferences. First, cooperation for emergency restoration between municipalities can be implemented from a humanitarian point of view. The question then is if there are differences in the extent of pro-sociality among municipalities in general, and in particular with respect to altruistic concerns regarding the actual disaster in question. These potential differences might affect the likelihood of acceptance. In order to investigate this, we include a measure of volunteer activity in each prefecture as a variable relating to the extent of pro-sociality among the municipalities and prefectures. The data comes from the 2011 survey on Time Use and Leisure Activities by the Statistical Bureau of the Japanese Ministry of Internal Affairs and Communications. It measures the percentage of people above 10 years old who participated in any volunteer activity in that year. Since the October 2011 survey was conducted after the disaster in March 2011, it also contains the volunteer activity for the disaster.

Second, we include the amount of donations from the inhabitants of the prefecture to the victims of the Great East Japan Earthquake. The Japanese Red Cross Society, one of the biggest organizations that collected donations for victims of the earthquake, provides data on the donations from each prefecture in Japan from March 2011 to March 2012. The data does not contain the donations that was sent directly to the head office of the Japanese Red Cross Society. Thus, if the ratio between the donations to the prefectural office and those to the head office is significantly different among prefectures, it does not accurately represent the exact donations from each prefecture. While both our measures of pro-social preferences could explain the willingness to help the affected municipalities with handling their waste, the second measure is directly related to the disaster itself. The relationship between donations and acceptance of waste is not clear. On the one hand the size of the donations could be a good measure of the extent of altruistic concerns. On the other hand, psychological studies suggest that there could be some sort of moral licensing (Monin and Miller, 2001), i.e. people who have undertaken a praiseworthy act, receive an implicit license for subsequently conducting a more selfish act. For example, Mazar and Zhong (2010) found that people become less altruistic after purchasing environmentally friendly products than after purchasing conventional products. It is possible that donations to help the victims might have lead to moral licensing and reluctance toward the acceptance of the disaster waste.

The third variable relating to social preferences is the proximity of each municipality to nuclear power plants. This variable is included to examine reciprocity reasons that could also be important for why a municipality accepts the disaster waste. Municipalities may be willing to accept the disaster waste because they could be harmed by a disaster in the future, and thereby are able to ask other municipalities for help as well. Specifically, this motive would be strong if the municipality is located near the nuclear power plant as the possibility that the request will be denied is higher. Data on the location of nuclear power plants was sourced from the Japan Atomic Industrial Forum, Inc. This is a dummy variable that takes the value one if there is any nuclear power plant within the boundaries of the municipality. As of March 2, 2011, there were 54 nuclear power reactors located in 17 municipalities in 13 prefectures in Japan.

The fourth variable on social preferences relates to the intention of prefecture toward the acceptance of disaster waste. Although each municipality makes decisions on the acceptance of the disaster waste independently, the prefecture which municipality belongs to might also influence the decision. This is because that the municipality can expect receiving cooperation and support on the wide area treatment from the prefecture if the prefecture is agreeing with the disaster waste acceptance. We therefore include a dummy variable of prefectural intention, which takes the value one if the prefecture expressed the intention of acceptance, supported the municipalities' decision of acceptance, or has already accepted the disaster waste with private waste management companies.

Economic efficiency

The main economic factor included in our analysis is the slack capacity of the incinerator plants. The idea is that municipalities will try to manage their incinerators efficiently from the viewpoint of economic rationality. If there is a larger slack capacity in incinerators, they can bring the operation of the facility to a more efficient level by accepting additional waste from other municipalities. Data on the slack capacity of incineration plants and that of disposal sites in each municipality were available from a survey by the Ministry of the Environment. The slack capacity of incineration plants is calculated as the difference between the annual capacity of the facility and the annual throughput. When annual throughput is larger than the planned capacity, the slack capacity can take a negative value.

Radiation risks

The effect of radiation risks is examined by three variables: the distance from Fukushima Daiichi, the percentage of agricultural workers to total population, and the percentage of population under age 15 to total population. The distance from the Fukushima Daiichi nuclear power plant represents a concern toward the issue. Social concern or social distance is potentially a function of spatial proximity (Akerlof 1997, Gleaser et al., 2002). Thus it is possible that people that live in municipalities close to the affected area have a closer social connection with the people in these areas, and are thus more concerned and more likely to support any help to the affected areas. In general, as the distance from the site increases, it is expected that understanding of the issue and the risk perception of disaster waste will be based on less knowledge and less information.

We also include information on the percentage of agricultural workers to total population and the percentage of population under age 15 to total population as explanatory variables. In municipalities that has large share of children in their populations, there may be stronger anxiety by parents over the effects of radiation on their children's health. Similarly, in the municipalities that has large share of agricultural workers, there may be more inhabitants who feel anxiety over the damage by rumors of pollution on the sales of their agricultural products.

Political orientation

The political orientation may affect probability of the acceptance of disaster waste[4]. We

[4] Rothman and Lichter (1987) suggest that political attitudes can affect the support or opposition to nuclear technology.

employ the percentage of the vote obtained by Liberal Democratic Party (LDP) and that by Democratic Party of Japan (DPJ) in the Japanese House of Councilors election in 2010, which is the latest national election result before the earthquake. LDP is a major conservative party that has held power almost continuously since its formation in 1955. DPJ is center left party founded in 1998 and controlled the government between 2009 and 2012. Although DPJ was in power at most of the time when wide area treatment is implemented, it is reasonable to expect that supporters of LDP would support the wide area treatment, while supporters of DPJ would not. This is because that LDP can be characterized as being more conservative and more patriotic party than the other. Patriotism can play a role in invoking the feeling of unconditional commitment. For example, various level of governments used the word *kizuna* which means strong ties between Japanese people, in the communication with public to explain the necessity of the wide area treatment. On the other hand, those who support DPJ have higher concern to environmental issues in general and would oppose the wide area treatment of disaster waste to avoid the risk of radioactive contamination.

Geography

To capture the characteristics of local areas, we employ population density, the income per capita, and region dummy variables. Population density and income variable are simple measure of the NIMBY phenomenon. It is reasonable to expect that when population density is high, there is more chance to have more residents in the neighborhood of facilities of waste treatment. Assuming that environmental quality is normal good, higher income can be correlated with environmental awareness. The region dummy comprises five areas: Hokkaido-Tohoku (the north area), Kanto (the east area, base category of dummy variable), Chubu (the middle area), Kansai (the west area), and Other areas (the south area).

We also include information on the pre-existing implementation of wide area treatment of municipal solid waste. While each municipality has the responsibility to the treatment of its household waste in Japanese waste management policy, the Ministry of the Environment has, since late 1990s, promoted wide area treatment because of economies of scale. Many municipalities form a coalition to treat household waste and share the incineration plants and/or disposal sites that are operated based on the cooperation among municipalities. A municipality that is used to accepting the solid waste of other municipalities might have less reluctance to the wide area treatment of disaster waste.

2.3.2 Model

We estimate the determinants for the municipalities' acceptance of disaster waste using a binary logit model. The model is:

$$\text{Prob}(Y = 1|\boldsymbol{X}) = \Lambda(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n) = \Lambda(\boldsymbol{X}'\boldsymbol{\beta}) = \frac{e^{\boldsymbol{X}'\boldsymbol{\beta}}}{1 + e^{\boldsymbol{X}'\boldsymbol{\beta}}}$$

where Y is a dummy variable that takes the value of one when the municipality is positive toward the acceptance of the disaster waste and $\boldsymbol{X}$ represents a vector of explanatory variables. We estimate three models based on the 2011, 2012, and 2013 data. Regarding the 2011 data and 2012 data, three kinds of municipalities are treated as positive toward the acceptance: municipalities that have been examining the possibility of acceptance; municipalities that have expressed the intention to acceptance; and those that have already accepted the disaster waste. With regard to estimations using the data of 2013, municipalities positive toward the acceptance are those that have already accepted the disaster waste.

There are large differences in the acceptance rate between the regions, in particular between eastern and western parts of Japan. Compared to eastern parts, there are very few municipalities that finally accepted waste in 2013 in western Japan. We will therefore also estimate models focusing only on the eastern part of Japan.

When a municipality already disposes municipal solid waste by wide area treatment with neighboring municipalities even before the earthquake, it is necessary for the municipality to obtain permission from other municipalities to accept disaster waste. Hence, all of these municipalities belonging to the group of wide area treatment are counted as host municipalities of the disaster waste when they agreed upon acceptance.

2.4 Results

Table 2.4 reports the results from the binary logit models with the acceptance of waste as the dependent variable, when we include all municipalities. Table 2.5 reports the results when we only include the municipalities in Eastern Japan. We will here focus on the results for all municipalities.

Most of the estimated marginal effects have signs that are in line with our hypotheses. However, the statistical significance varies between the data from 2011—before the detection of the high radiation level in the incineration ashes of the municipal solid waste in Tokyo—and the data from 2012 and 2013.

The amount of donations is positive and statistically significant in the 2013 model and the number of volunteers is statistically significant in 2012 model. In contrast, the coefficients of these variables are not statistically significant in 2011 model. In municipalities with higher amount of donations, the likelihood of accepting waste is higher, and the effect is statistically significant in the 2013 model. The sizes of the marginal effects are small, albeit non-negligible. For example, for the 2013 model if donations increase by one standard deviation, the probability that a municipality accepts waste increases by 0.01 units. The measure of volunteer activity is also positively correlated with the likelihood of accepting waste for the 2012 model. Thus, both our measures of pro-sociality are positively related to acceptance, and since the amount of donations and the level of volunteer activity are positively related, any type of moral licensing is not so strong so that it counteracts the effect of pro-sociality on the acceptance of waste.

Results related to the reciprocity reveal that proximity to a nuclear power plant has a statistically significant and positive marginal effect in the 2012 and 2013 models, but not in the 2011 model. Since the 2011 data was based on responses from municipalities before the serious contamination of incineration ash in Tokyo was found, it is probable that decisions in 2011 did not seriously take radiation risks into consideration. After June 2011, concerns toward radioactive contamination increased among the citizens and many municipalities had become more negative towards handling disaster waste. On the other hand, a municipality that has a nuclear power plant within its boundaries may not change the attitude because they would expect other municipalities to help if a severe nuclear accident occurred in their own municipality. This reciprocity motivation can lead a municipality near the nuclear power plants to acceptance.

The impact of the prefecture’s intention is negative and statistically significant in models that use the 2012 data. On the other hand, the effect is positive and statistically significant in models that use the 2011 and 2013 data. While the negative coefficient in models with the data from 2012 is difficult to interpret, the results found in the 2011 and 2013 model suggest that the positive intentions of the prefecture is associated with higher probability of accepting disaster waste by municipality. The influence of the relationship with prefectural government might not be weak in coordinating the inter-municipal transfer of disaster waste.

While the above variables are mostly related to non-economic motivations for acceptance, the estimated results suggest that economic incentives to some extent influence the decision to accept disaster waste, in particular just after the earthquake. Looking at 2011 data for all municipalities, the slack capacity of the incineration plants and disposal sites is positively correlated with the decision to accept disaster waste. In 2012 and 2013 models, however, there is weaker evidence for the effect of economic incentives. In particular, if we look at 2012 and 2013 data for the municipalities in Eastern Japan, it seems that the economic efficiency does not play a role in the decisions.

The results related to the distance to the Fukushima Daiichi nuclear power plant also suggest that the distance itself was an important factor. The estimated marginal effects with the data from 2013 show that the distance from the Fukushima Daiichi is negative and statistically significant. This suggests that there is a stronger concern about the affected areas and a stronger willingness to help in municipalities that are close to the affected area. The size of the marginal effect is sizeable, for the 2013 model an increase in distance corresponding to a standard deviation increase, decrease the probability of acceptance by 0.26 units. The results for municipalities in Eastern Japan show that the distance to the Fukushima Daiichi nuclear power plant is positive and statistically significant in models that use the 2011 data, while the effect is negative and statistically significant in models that use the 2013 data. The results suggest that relationship between the distance from the site and the willingness to accept the waste has considerably changed between these periods.

The ratio of the population working in the agricultural sector is statistically significant and negative in all models. The likely explanation is that the in areas with a lot of agricultural production there was a fear that acceptance of tsunami waste could create a negative image of their products. On the contrary to our hypothesis, coefficients of population under age 15 is mostly insignificant.

The results relating to the political preferences show that the percentage of the vote obtained by DPJ in the Japanese House of Councilors election in 2010 has positive and statistically significant coefficient effect in the 2011 model. On the other hand, the result changes to negative and statistically significant coefficient in 2012 and 2013 models.

Although DPJ was in power most of the time during the implementation of wide area treatment, the residents who support DPJ might have higher concern for environmental issues in general and oppose the wide area treatment of disaster waste. In the election held in December 2012, ironically, the DPJ lost around 75% of its pre-election seats in the House of Representatives.

2.5 Conclusions

This chapter investigated the determinants for the municipalities' acceptance of disaster waste resulting from the Great East Japan Earthquake. Our results suggest that the social preferences were important for the decision to accept waste, more so than economic reasons. Previous studies have focused on economic reasons for transfer of waste between regions or municipalities. Thus, what we show is that other reasons could explain the decision as well.

Many news articles reported that inhabitants protested or opposed the acceptance of disaster waste while hoping for the revival of the stricken area. Although the statistical evidence is not so strong, our results supports that the opposition to some extent comes from the inhabitants' anxiety over radiation contamination from the disaster. Information disclosure and communication about the radiation risks are important, especially for municipalities that are located far from the damaged area. The finding pertains to many NIMBY problem and the wide area treatment of other hazardous waste. On the other hand, variables related to pro-sociality positively affect the municipalities' acceptance of disaster waste. We could not find any evidence of moral licensing or negative relation between pro-social behaviors. Understanding how pro-social behaviors can positively affect cooperation is important for policy interventions for disaster recovery and the support of a feeling of YIMBY, i.e. Yes in my Backyard. It would be helpful for the ministry in the central government when it comes to coordinating the decision making of municipalities in different areas and at different levels.

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Figure 2.1: The percentage of positive municipalities from 2011 to 2013

Figure 2.1.1 Percentage as of 2011

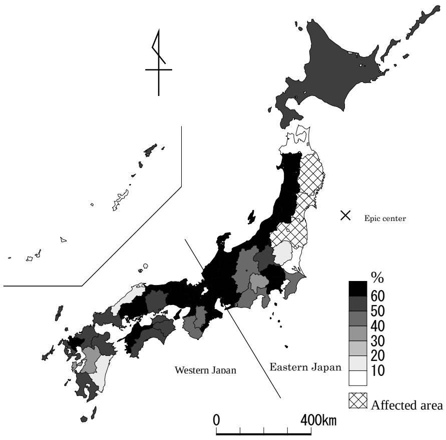

Figure 2.1.2 Percentage as of 2012

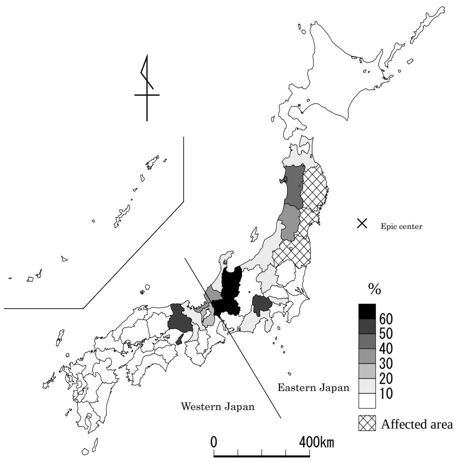

Figure 2.1.3 Percentage as of 2013

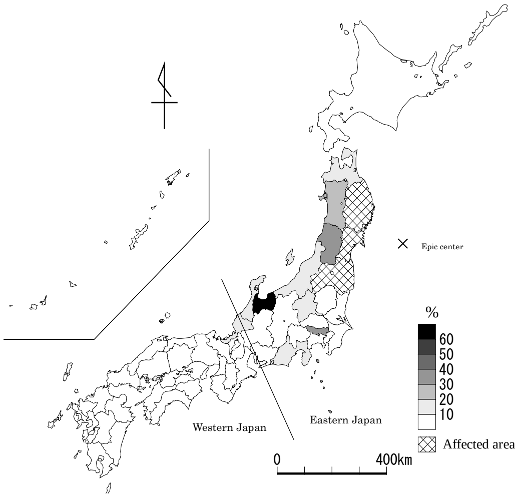

Table 2.1: The number of municipalities and acceptance

	2011			2012			2013		
	West	East	Total	West	East	Total	West	East	Total
Positive	395	486	885	46	132	178	2	74	76
Negative	308	403	716	657	757	1,414	703	815	1,516
Total	703	889	1,592	703	889	1,592	705	889	1,592

Note: Positive municipalities for the 2011 and 2012 data means that have been examining the possibility of acceptance, that expressed the intention of acceptance, or that have already accepted the disaster waste. Positive municipalities for the 2013 data means that have already accepted the disaster waste.

Table 2.2: The flow of the wide area treatment

Miyako area	
1. Separation by machine and hand	Fist temporary site
2. Separation by hand	Second temporary site
3. Measurement of the radiation level	
4. Measurement of the radiation level	Harbor in Iwate
5. Loaded onto a ship	
Osaka city	
6. Unloading of containers	Harbor in Osaka
7. Measurement of the radiation level	
8. Separation by machine	Transshipment facility
9. Measurement of the radiation level	
10. Incineration with municipal solid waste	Incineration plant
11. Measurement of the radiation level	
12. Final disposal with municipal solid waste	Final disposal site
13. Measurement of the radiation level	

Table 2.3: Descriptive statistics

	Average	Min.	Max.	SD
Donation (yen/person, prefectural level)	0.81	0.14	2.69	0.52
Volunteer (%, prefectural level)	3.31	2.00	6.90	1.05
Proximity of nuclear plant (dummy)	0.01	0.00	1.00	0.10
Prefecture intention (dummy)	0.40	0.00	1.00	0.49
Slack capacity of incineration plant (10000 t/per year)	3.14	-0.21	120	5.91
Slack capacity of final disposal site (10000 t)	2.64	0.00	430	18.33
Distance from Fukushima Daiichi (100 km)	5.91	0.73	22.38	3.63
Population under age 15 (%)	12.70	4.25	21.81	2.28
Agricultural workers (%)	5.33	0	59.36	5.79
Population Density (100 person/km^2)	2.04	0.00	50.07	5.43
Wide area treatment of municipal solid waste (dummy)	0.58	0.00	1.00	0.49
Income (million yen)	2.757	1.908	5.646	0.393
Votes cast for DPJ (%)	30.655	1.674	49.611	5.631
Votes cast for LDP (%)	28.291	1.319	60.431	7.380

Note: SD is standard deviation.

Table 2.4: Marginal effects, logit models on the decision to accept waste in all of Japan

	All of Japan		
	2011 Data	2012 Data	2013 Data
Donations	-0.013	-0.020	0.022 **
	(0.027)	(0.017)	(0.010)
Volunteers	0.024	0.032 ***	0.004
	(0.016)	(0.008)	(0.007)
Proximity of nuclear plant	0.068	0.109 **	0.108 ***
	(0.119)	(0.049)	(0.026)
Prefecture intentions	0.109 ***	-0.060 ***	0.064 ***
	(0.034)	(0.018)	(0.018)
Slack capacity of incineration plant	0.026 ***	0.004 ***	0.000
	(0.005)	(0.001)	(0.001)
Slack capacity of final disposal site	0.009 **	0.000	0.001 ***
	(0.004)	(0.000)	(0.000)
Distance from Fukushima nuclear plant	0.000	-0.011	-0.020 **
	(0.010)	(0.007)	(0.008)
Population under age 15 ($*10^2$)	-0.001	0.009 **	0.001
	(0.006)	(0.004)	(0.003)
Agricultural workers	-0.005 **	-0.015 ***	-0.005 **
	(0.002)	(0.003)	(0.002)
Population Density	-0.008 ***	-0.002	-0.003
	(0.002)	(0.001)	(0.002)
Wide area treatment of MSW	0.191 ***	0.007	0.015
	(0.025)	(0.015)	(0.011)
Income	0.046	-0.007	0.028
	(0.047)	(0.028)	(0.020)
Votes cast for DPJ	0.009 ***	-0.008 ***	-0.002 *
	(0.003)	(0.002)	(0.001)
Votes cast for LDP	-0.002	0.000	0.001
	(0.002)	(0.001)	(0.001)
Area Dummy	Yes	Yes	Yes
Observations	1,507	1,592	1,592

Note: Standard errors are given in parentheses. * p< 0.10; ** p < 0.05; *** p < 0.01.

The closest 44 and the farthest 41municipalities from affected areas did not receive a request from the government to dispose of the disaster waste and are thus not included in 2011's data.

Table 2.5: Marginal effects, logit models on the decision to accept waste in East of Japan

	East of Japan		
	2011 Data	2012 Data	2013 Data
Donations	0.141 ***	0.023	0.042 **
	(0.041)	(0.024)	(0.018)
Volunteers	0.052 **	0.050 ***	0.003
	(0.021)	(0.012)	(0.012)
Proximity of nuclear plant	0.132	0.155 **	0.188 ***
	(0.143)	(0.065)	(0.045)
Prefecture intentions	0.150 ***	-0.048	0.105 ***
	(0.043)	(0.029)	(0.032)
Slack capacity of incineration plant	0.028 ***	0.003	0.001
	(0.007)	(0.002)	(0.001)
Slack capacity of final disposal site	0.005 *	0.001	0.001
	(0.003)	(0.001)	(0.001)
Distance from Fukushima nuclear plant	0.038 **	-0.006	-0.038 **
	(0.018)	(0.014)	(0.015)
Population under age 15 ($*10^2$)	0.000	0.014 **	0.001
	(0.009)	(0.006)	(0.005)
Agricultural workers	-0.004	-0.022 ***	-0.009 **
	(0.003)	(0.004)	(0.004)
Population Density	-0.011 ***	-0.002	-0.005
	(0.003)	(0.002)	(0.003)
Wide area treatment of MSW	0.248 ***	0.022	0.027
	(0.032)	(0.024)	(0.019)
Income	0.050	-0.031	0.060 *
	(0.064)	(0.053)	(0.035)
Votes cast for DPJ	0.005	-0.009 ***	-0.004 *
	(0.004)	(0.003)	(0.002)
Votes cast for LDP	-0.001	0.001	0.002
	(0.003)	(0.002)	(0.002)
Area Dummy	Yes	Yes	Yes
Observations	845	889	889

Note: Standard errors are given in parentheses. * $p< 0.10$; ** $p < 0.05$; *** $p < 0.01$.

The closest 44 and the farthest 41municipalities from affected areas did not receive a request from the government to dispose of the disaster waste and are thus not included in 2011’s data.

Chapter 3

Does Conflict Matter?

Spatial Distribution of Disposal Sites in Japan

3.1 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 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. The few examples are Stafford (2000) and Lauriand and Funderburg (2014). Stafford (2000) examined the impact of environmental regulations on the location of hazardous waste management firms. Laurian and Funderburg (2014) 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. Since existing studies (Stafford 2000; Lauriand and Funderburg 2014) use a dummy variable of location as dependent variable, they cannot take the extent of spatial concentration into consideration. Moreover, these studies do not address spatial correlation in their estimation.
We focus on the number of disposal sites per capita in our estimation and consider spatial dependence by using spatial econometric techniques. 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 3.3 introduces the method used for estimation as well as the study's empirical strategy. Section 3.4 explains the model specification and data, and Section 3.5 explains the results of the spatial concentration analysis of disposal sites and conflict. Finally, Section 3.6 concludes and discusses policy implications.

3.2 Background and Hypothesis Development

In Japan, industrial waste is usually disposed in disposal sites that are managed by private companies, whereas municipal solid waste is disposed in those that are managed by local municipalities. Furthermore, the prefectural governments are responsible for industrial waste management policy. Figure 3.1 classifies the types of disposal sites in Japan[5]. 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 3.2 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[6]. 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,*

[5] 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.

[6] Shinkuma and Managi (2012) investigate the effect of final disposal cost on the rate of illegal disposal in Japan although their results suggest that it is statistically insignificant.

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 for prefectural permission to construct the disposal site. Some local governments promulgate local ordinances that require waste management companies to make an agreement with nearby residents on site constructions. However, enforcement of the ordinance is weak in general. Thus, permission is usually granted if legal 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 3.3 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 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 concerned about the risks of pollution from disposal sites. 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 the government. They are skeptical about the safety and efficiency of the disposal methods being employed. Thus, 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). Residents may also be concerned about the future risks of 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 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).

Sasao (2004) indicates that residents in rural areas more strongly oppose accepting waste from other municipalities than those in urban areas, and resident in the municipalities with their own landfills more strongly oppose accepting it than those in municipalities without them. To mitigate such antipathy, a fair siting procedure is important in increasing residents' willingness to host an unwanted 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. 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 thus strongly oppose to the construction of disposal sites. Therefore, conflict is likely to take place in an area where there is higher possibility of receiving* *environmental or economic damage from the inappropriate operation of disposal sites, such as in the area that is dependent on the use of groundwater.*

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

3.3 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). The Moran's I statistic is defined as follows:

$$Moran's\ I = \frac{N}{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}} \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

where $(x_i - \bar{x})$ is the deviation of an attribute for municipality x_i , $w_{ij}$is the spatial weight between municipalities i and j, N represents the total number of municipalities, and $\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}$ is the aggregate of all the spatial weights.

$$w_{ij} = \frac{c_{ij}}{\sum_{i=1}^{N} c_{ij}} \qquad c_{ij}(i, j = 1,2, \dots, N)$$

where c_{it} takes the value of one when municipalities i and j are contiguous, and zero otherwise. The spatial weight matrix w is based on k-nearest neighbors, given that the centroid distances from each municipality i to all municipalities $j \neq i$ be ranked as follows: $d_{\mathrm{ij}(1)} \leq d_{\mathrm{ij}(2)} \leq \dots \leq d_{\mathrm{ij}(n-1)}$.

Then, for each $k = 1, \dots, n-1$, the set $N_k(i) = \{j(1), j(2), \dots, j(k)\}$ contains k closest units to i. In this study, the spatial weight matrix w is generated using coordinates based on each municipality's five nearest neighbors. The reason for using information on five nearest neighbors is that the average number of neighboring municipalities that share a common border in Japan is five. For computational ease, we use a dummy variable c_{it}, which reflects the contiguous relation—rather than the geographical distance—between municipalities. In general, a Moran's I value near +1.0 indicates clustering, while an index value near -1.0 indicates dispersion, and 0 indicates randomness. For industrial waste disposal sites, the global Moran's I is 0.122, where a P value of 0.000 is obtained under the null hypothesis of spatial independence (Moran's I is zero). 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)[7]. 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

[7] 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.

calculated the Anselin local Moran's I statistic (Anselin 1995). The local Moran's I statistic is defined as follows:

$$Local\ Moran's\ I_i = \frac{(x_i - \bar{x})}{\sum_{i=1}^{N}(x_i - \bar{x})^2 / N} \sum_{j=1}^{N} w_{i,j}(x_j - \bar{x})$$

A positive local Moran's I value indicates that municipalities with similar values surround a municipality, whereas a negative local Moran's I value indicates that municipalities with different values surround the municipality. We also estimate the Getis-Ord Gi* statistic (Getis and Ord 1992; Ord and Getis 1995), which is defined as follows:

$$G^* = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{i,j} x_i x_j}{\sum_{i=1}^{N}\sum_{j=1}^{N} x_i x_j}$$

The G^* statistic returned for each municipality is a Z score. A positive and larger value indicates the more intense the clustering of high values, which implies a hot spot. A negative and smaller value indicates the more intense the clustering of low values, which implies a cold spot. The specific test results and a description of the clusters are presented in the Figures 3.4 and 3.5. As shown in these figures, we find that the local Moran's I and G^* statistics tend to be high for municipalities in Hokkaido prefecture. This is reasonable, since Hokkaido is the prefecture with the largest livestock production in Japan, and there are many livestock farmers especially in the southeastern area. According to Hokkaido Prefecture (2012), half of the total industrial waste in Hokkaido prefecture comprises animal manure. Thus, there is high potential for supplying waste to the disposal sites. In addition, Hokkaido is the largest prefecture in terms of land area, with lower population compared to others. Therefore, availability of land for waste disposal is higher than other prefectures.

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 location data are aggregated at the municipality level for municipalities that share a border with at least one other municipality. Municipality-level data provide us detailed information to investigate the decision making of waste management companies for site location, by considering the characteristics of local communities in proximity to the disposal sites. To analyze the concentration of disposal sites adequately, prefectural-level data is too crude and will not reflect the geographical distribution and their determinants accurately. For instance, one can consider a case where all disposal sites are concentrated in a few municipalities of a prefecture as well as the case where these are distributed evenly in all municipalities, even though the total number of disposal sites in a prefecture remains the same. A spatial Tobit model is defined as follows:

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

$$y_i^* = (I_n - \rho W)^{-1} X\beta + (I_n - \rho W)^{-1}\varepsilon$$

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; X is a vector of characteristics describing the site; W is spatial weight matrix; and β and ρ are parameters. The negative values from vector $\boldsymbol{y^*_i}$ is set to zero to reflect sample truncation at zero.

The spatial interdependence induces a truncated multivariate normal distribution (TMVN) for the latent variable, and thus takes the following form:

$$y_i^* \sim TMVN(\mu, \Omega)$$

$$s.t. \mu = (I_n - \rho W)^{-1} X\beta$$

and $\quad \Omega = \sigma_\varepsilon^2 [(I_n - \rho W)'(I_n - \rho W)]^{-1}$

subject to the vector of linear inequality restrictions $a \leq y^* \leq b$, where the truncation bounds depend on the observed values of y.

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, $\boldsymbol{y_i}$ 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:

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

$$y_i^* = (I_n - \rho W)^{-1} X\beta + (I_n - \rho W)^{-1}\varepsilon$$

3.4 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 3.1.

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 higher incidences of conflict over the construction of disposal sites. 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[8] and the investigation of land prices within each prefecture. The unemployment rate captures the environmental justice. Laurian and Funderburg (2014) found that towns in France with large vulnerable populations are more likely to host the construction of waste incineration facilities. 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[9]. 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 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[10]. 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

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

[9] 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.

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

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 of waste processed for disposal within the prefecture[11]. 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).

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

3.5 Results

3.5.1 Spatial Concentration of Disposal Sites

We estimate models that take the number of industrial waste disposal sites per capita as the dependent variable.[12] 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 are presented in Table 3.2. For completeness, we also report the estimation results by the aspatial Tobit and Probit models[13]. 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 3.2 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 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 3.2 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

[12] As a robustness check, we estimated our model using the number of disposal site per area as a dependent variable. The result is similar to that of the model using the number of disposal site per capita as a dependent variable.
[13] Aspatial Tobit models and Probit models are those that do not consider spatial correlations.

in contrast to that of Laurian and Funderburg (2014). 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 specification. 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.

3.5.2 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 3.3. 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 3.2 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.

3.5.3 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. We consider three sets of samples for our study: 1) Municipalities with a completed disposal site, but without a conflict case; 2) Municipalities without a completed disposal site, but with a conflict case; and 3) Municipalities with both a completed disposal site and a conflict case. We combine these three sets and assume that these are municipalities with construction plans to build a disposal site. This procedure omits municipalities that had plans for disposal sites that are under construction or were never completed, but never experienced conflict, due to unavailability of data. The omission of the disposal sites that are under construction and are without conflict might lead to underestimation of the negative impact of the conflict case on location decision, while that of the disposal sites that were never completed and are without conflict might lead to overestimation of the impact.

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 3.4. 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 3.2.

3.6 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. First, the concentration of waste-related facilities in certain areas suggests that the environmental impact of such facilities can be extremely high in these areas. To activate the local economy, some municipalities might support the location of disposal sites in certain areas. However, doing so might cause intensive pollution 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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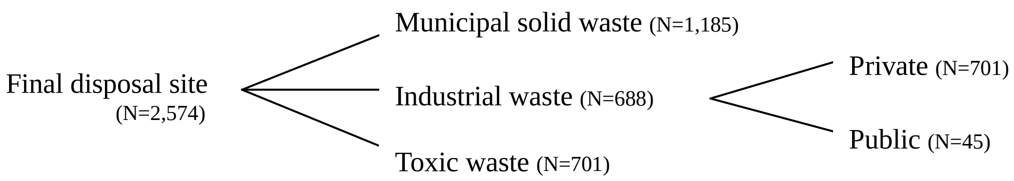
Figure 3.1: Classification of disposal sites in Japan



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

Figure 3.2: Locations of industrial waste disposal sites throughout Japan

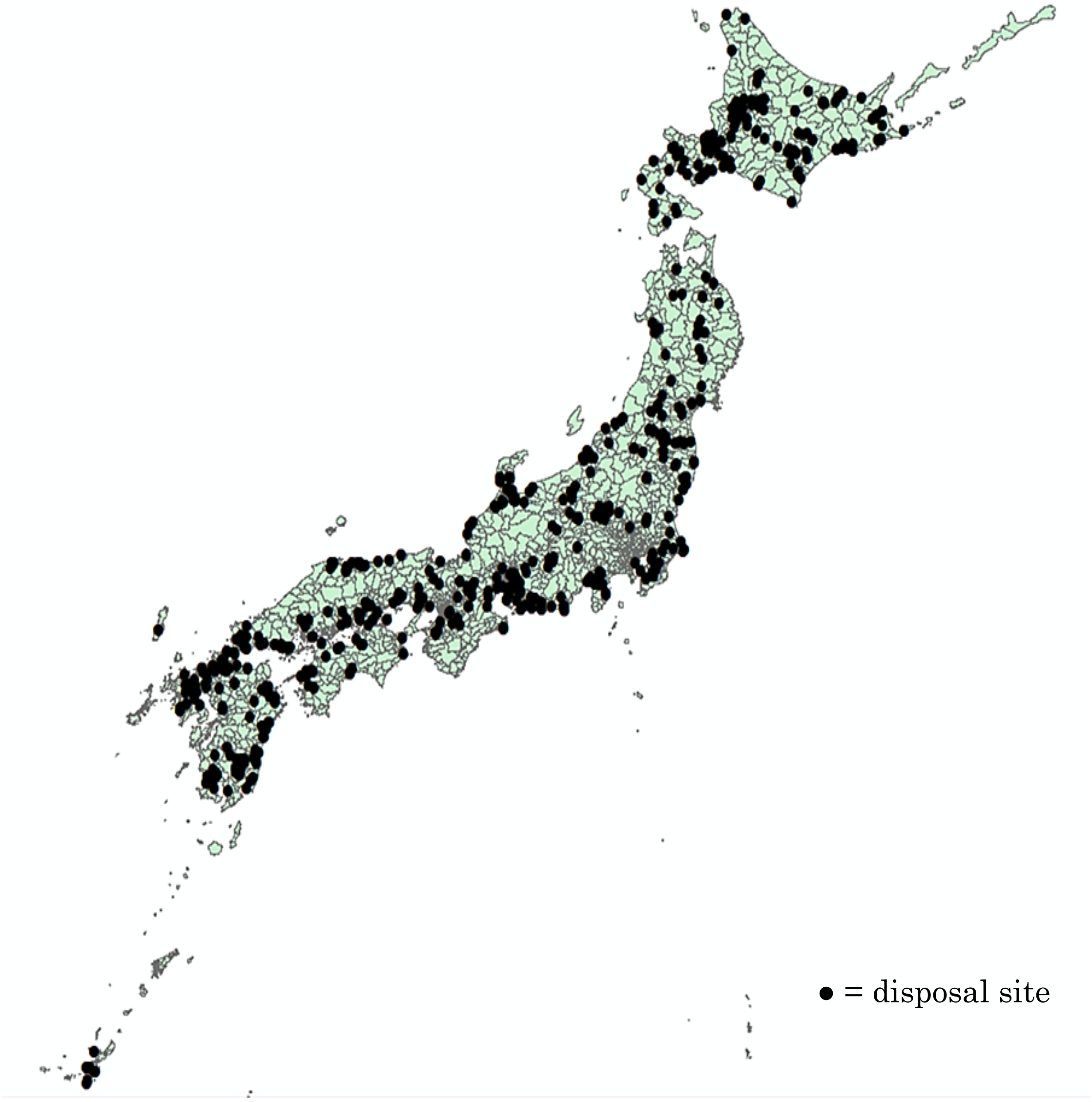
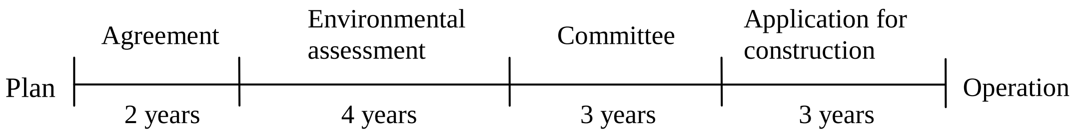


Figure 3.3: Example of the siting process without conflict



Source: National Federation of Industrial Waste Management Associations (2012)

Figure 3.4: Spatial clustering of final disposal sites via the Anselin Local Moran's *I*

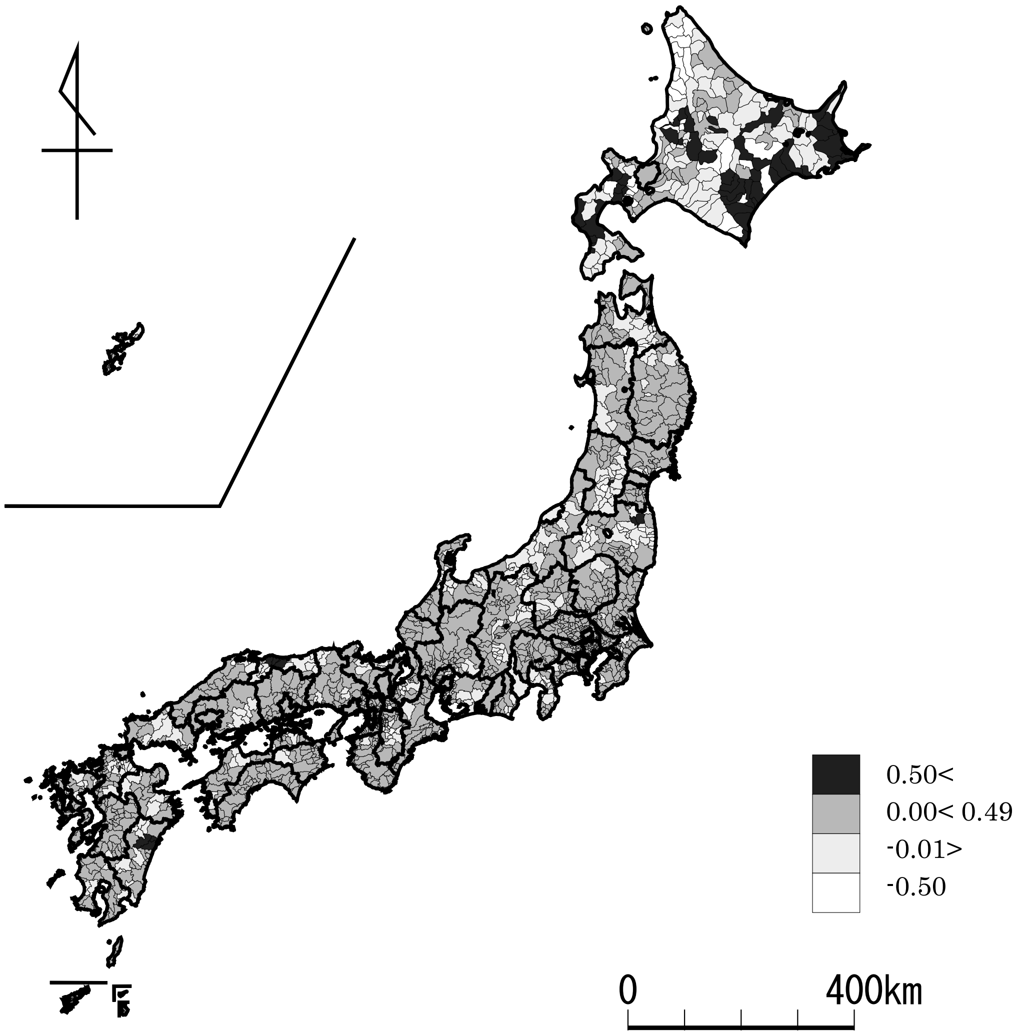


Figure 3.5: Spatial clustering of final disposal sites via Getis–Ord *Gi**

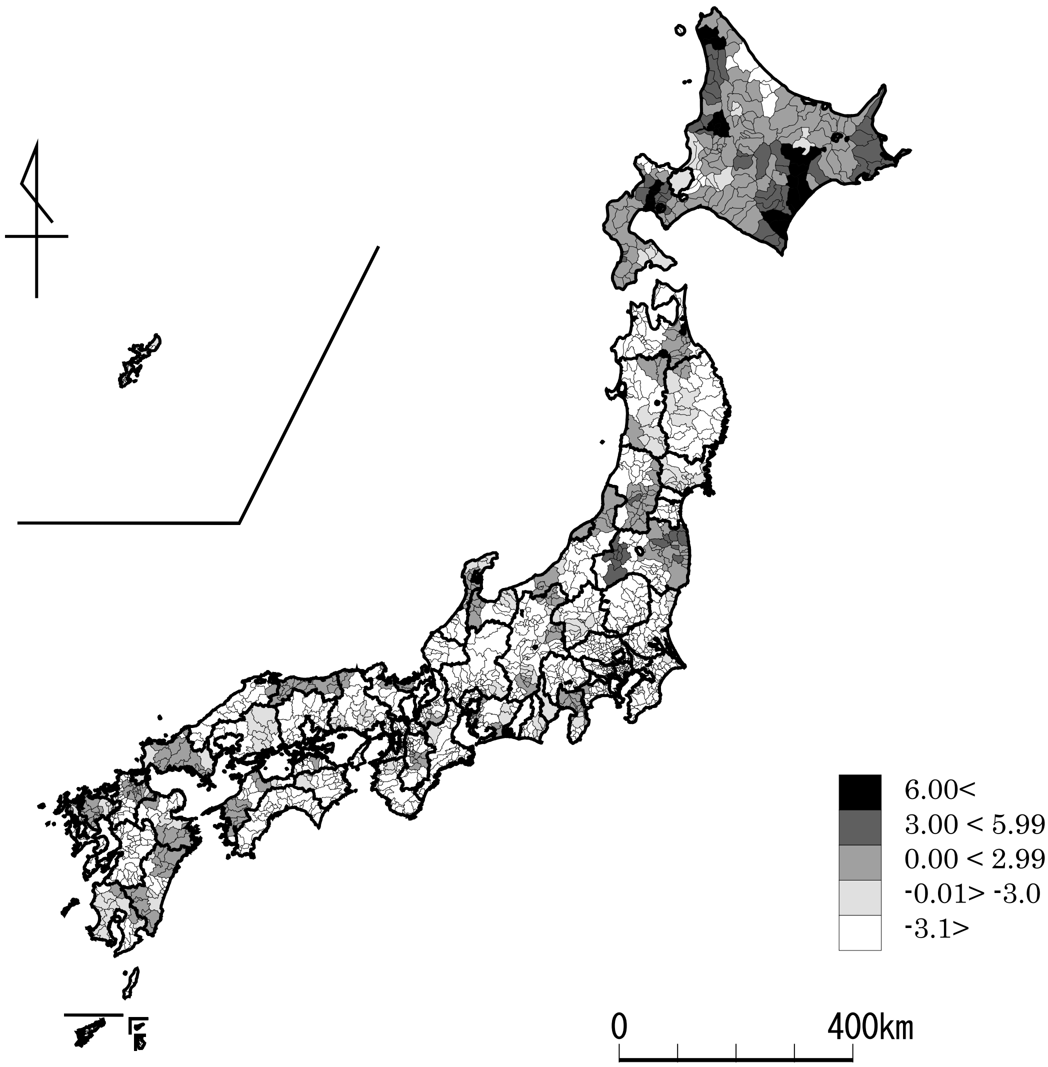


Table 3.1: Descriptive statistics

	Unit	Mean	Min	Max	SD
Disposal site for industrial waste	sites/10,000 persons	0.125	0.000	6.485	0.496
Disposal site for hazardous waste	sites/10,000 persons	0.068	0.000	15.038	0.474
Intermediate site for industrial waste	sites/10,000 persons	1.306	0.000	64.088	2.264
Publicly supported disposal site	1 = yes, 0 = otherwise	0.027	0.000	1.000	0.163
Land price	10,000 yen	6.111	0.162	546.700	22.711
Unemployment	%	6.327	0.000	22.718	2.123
Population density	1,000 persons/km^2	4.127	0.001	218.815	18.701
Agricultural workers	%	4.940	0.000	52.333	5.187
Manufacturing workers	%	8.131	0.492	23.831	4.094
Municipal financial stability index	points	0.500	0.070	2.130	0.282
City	1= yes, 0= otherwise	0.461	0.000	1.000	0.499
Number of landslide	1,000 spots	22.025	2.064	63.974	11.241
Nature reserve	1 = yes, 0 = otherwise	0.203	0.000	1.000	0.402
Amount of groundwater usage	million m^3	6.219	0.210	69.087	10.204
Total manufacturing revenue	billion yen	17.013	0.000	1208.886	48.038
Amount of industrial waste	10 million t	1.178	0.123	3.576	1.017
Length of highway infrastructure	km	266.661	18.200	894.400	236.344
Conflict	1 = yes, 0 = otherwise	0.129	0.000	1.000	0.336

Table 3.2: Estimation results (Dependent variable: the number of disposal sites for industrial waste per capita)

	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< 0.10; ** p < 0.05; *** p < 0.01. The correlation between the variable for the number of hazardous waste disposal sites and that for the distance of highway infrastructure is 0.699, while that of the variable for the number of hazardous waste disposal sites and that for the amount of industrial waste is 0.632.

Table 3.3: Estimation results (Dependent variable: the dummy variable of conflict over the plan for a disposal site for industrial waste)

	Spatial Probit		Aspatial Probit	
	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< 0.10; ** p < 0.05; *** p < 0.01. The correlation between the variable for the number of hazardous waste disposal sites and that for the distance of highway infrastructure is 0.699, while that of the variable for the number of hazardous waste disposal sites and that for the amount of industrial waste is 0.632.

Table 3.4: 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< 0.10; ** p < 0.05; *** p < 0.01.

Chapter 4

Where did our NIMBY go?

The Spatial Concentration of Waste Disposal Sites in Japan

4.1 Introduction

NIMBY, “not in my backyard” is a serious concern in environmental management. While understanding the social necessity of facilities such as waste disposal sites, nuclear power plants, prisons, airports, dams, etc., local communities often refuse to host these facilities themselves. Japan provides an excellent setting to approach this problem because of its high population density and the scarcity of land for refuse disposal. In addition, Japanese experience of NIMBY issues is the lesson for rapidly industrializing countries. The amount of waste increased dramatically from 1970s with economic growth and most waste was dumped untreated into landfill sites, like recent rapidly industrializing countries. With landfill and environmental quality contaminating, public awareness and concern escalating as result of lacking management of disposal sites, and civil society movements on the rise in many local communities. As a result, in 2012, the number of industrial waste disposal sites decreased by half in comparison with 20 years ago, and available capacity of disposal sites is only 15 years. Governments struggle with the problem of keeping sufficient capacity of waste disposal sites in the face of deep apprehension and strong opposition from residents (Frey and Oberholzer-Gee 1996). Firms also face a dilemma posed by finding the optimal location for operation of sites against the strong opposition of residents. While waste management companies focus on efficiency and profit maximization in location decisions of their sites, they do not take sufficient consideration for environmental risk and damage due to the operation of disposal sites. Therefore, the competitive market of waste dsposal might raises the posibility of social inequities or environmental injustice in the distribution of waste disposal sites related to NIMBY.

The purpose of this chapter is to understand the mechanisms of spatial distribution and location decisions of waste disposal sites from a long-term perspective. Using spatial econometric techniques and unique data from 2,535 disposal sites from 1992 to 2012 in Japan, we investigate the changes in spatial concentrations and factors that impact location decisions of private disposal sites for industrial waste. We also investigate the characteristics of communities in which the number of disposal sites has been increasing or decreasing.

Previous studies on the location of waste treatment facilities have mainly focused on normative issues. Kunreuther and Kleindorfer (1986) propose a sealed-bid mechanism to elicit citizens' willingness to accept facilities. Minehart and Neeman (2002) present a modified second-price auction procedure for choosing a site location. Swallow et al. (1992) propose a three-phased approach that integrates the technical, economic, and political dimensions related to the landfill-siting process.

The first contribution of this chapter is to address how the structure of distribution of disposal sites changes over time by using a unique data set on geographical location of industrial waste disposal sites from 1992 to 2012. Under a competitive market, it is important to identify the optimal locations for the operation of sites, and waste management companies might tend to choose specific municipalities with certain characteristics. Thus, there is likely to be an unequal distribution of waste disposal sites. Japan provides an excellent setting to test this hypothesis because of its high population density and the scarcity of land for waste disposal. Furthermore, a disposal site requires a considerable amount of land, and in many cases, it is difficult to redevelop such sites after the completion of operations. However, since long-term location data of private disposal sites of industrial waste has never been available, there has been no study to examine the tendency of distribution and change in factor that affects location decisions of waste disposal sites. We overcome this point by requesting disclosure of the data on disposal site locations from all Japanese prefectural governments. As a result, thanks to the survey response rate of 100%, we were able to collect the location data of 2,535 private and public industrial waste disposal sites that operated in the period from 1992 to 2012.

The second contribution is to understand how the location of disposal sites is decided in a competitive market. In general, the political equilibrium and market equilibrium, as well as socially optimal siting, differ. The firms pursue the profit maximization or cost minimamization in location decisions of their sites, while govrnment focuse on the political equilibrium. Thus, there is likely to be differences between the location decisions factor of public disposal sites and private disposal sites. In addition, the factor that affect location decisions of private disposal sites might depend on the change in market structure. Therefore, it is important to capture the change in market structure that attract the concentrations and inequitable distributions of disposal sites in the competitive market. Previous studies that have investigated the empirical aspect of location decision-making for unwanted facilities focused on the political distribution of unwanted facilities, Feinerman (2004), Aldrich (2008), Lauriand and Funderburg (2014). Feinerman (2004) focused on the political aspects of the siting process to resolve conflicts with residents. Aldrich (2008) focused on the relationship between local civil society and the location of controversial facilities, such as nuclear power plants in Japan. Laurian and Funderburg (2014) focused on the location of public incinerators in France from the viewpoint of environmental justice. While these studies relate to public site selection under political equilibrium, there has been little research done concerning the location decisions of private disposal sites under perfect competition. Stafford (2000) examines the impact of environmental regulations on the location of hazardous waste management facilities. Ishimura and Takeuchi (2015) show that there is spatial concentration of disposal site for industrial waste in some areas in recent year, 2012.

The next section describes the background of industrial waste management in Japan. Section 4.3 introduces the method used for estimation, as well as the study's empirical strategy. Section 4.4 explains the model specification and data, and Section 4.5 explains the results of the spatial concentration analysis of disposal sites. Finally, Section 4.6 concludes and discusses policy implications.

4.2 Industrial waste management policy

In Japan, waste defined in the Waste Management Low of 1970 is classified as "industrial waste" or "municipal solid waste", with separate regulations. Industrial waste is usually disposed of in sites that are constructed and managed by private waste management companies, whereas municipal solid waste is disposed in sites managed by local municipalities[14]. The prefectural governments are responsible for industrial waste

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

management policy. 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. Although prefectural governments are responsible for sitting industrial waste management policy in Japan, they are obliged to approve the construction as long as the company's application fulfills the legal conditions of the Japanese Waste Disposal Law. Thus, the prefectural governments cannot limit the number and location of private disposal sites in their own prefectures.

Figure 4.1 shows the number of operating industrial waste disposal sites for each year over the study period. The number of disposal sites increased between 1992 and 1998. After that, the number of disposal sites decreased from 1,571 sites in 1999 to 1,036 sites in 2012. Additionally, Figures 4.2 and 4.3 shows the locations of the industrial waste disposal sites in operation in 1992 and 2012, throughout the country. 72 percent of Japanese municipalities in 1992 and 75 percent of Japanese municipalities in 2012 had no industrial disposal sites at all. Therefore, there is a possibility there is a locational concentration of waste disposal sites in some distinct areas.

What is the mechanism behind the location decisions of disposal sites? A general problem facing a private waste disposal sites relative to its location decision is the potential demand for landfill sites and cost for waste disposal. The waste management companies face a location selection that involves several considerations that will impact on the profit maximization. A primary issue is the demand for waste disposal. Since the region with higher industrial activity has higher potential for waste disposal, the waste management companies have a preference for these regions.

The secondly issue is the land cost and transportation cost. Although industrial cities or densely populated cities generate large volumes of industrial waste, the land price of these regions is higher. On the other hand, the firms generating waste select the nearest disposal site and lower disposal price. In other words, the firms select a disposal site by comparing the sum of the transportation costs and disposal costs. Then, if the infrastructure improvements for

total as of April 2015.

transportation decreases the transport cost, the disposal sites would move outward from urban area.

Third issue is the transaction costs and opportunity costs impact on the location decision. The local communities often refuse unwanted facilities, such as waste disposal sites. There are several cases where local communities actively campaign against the construction and operation of disposal sites. According to the study done by Ishimura and Takeuchi (2015), the conflict with residents tend to take place in urban area and decrease the possibility of site location. Laurian and Funderburg (2014) find that towns in France with large vulnerable populations are more likely to host the construction of public waste incineration facilities. Therefore, waste management companies tend to locate disposal sites in areas in which construction is easier−that is, areas with an existing disposal site and lower transaction costs as well as opportunity costs.

Finally, the environmental protection impacts on the location decision. In Japan, the waste management company must submit an environmental assessment report when applying for prefectural permission to construct the disposal site. It is difficult for waste management company to obtain permission in the area with strict regulations for environmental protection.

4.3 Spatial Dependency in Disposal Site Location

Firstly, we investigate whether the disposal site location has been concentrated spatially for a long time. To address this question, we estimate the global Moran's I statistic which is a measure used to test spatial dependency (Anselin 1988, 1995). The global Moran's I statistic is defined as follows:

$$Moran's\ I = \frac{N}{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}} \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^{N}(x_i - \bar{x})^2}$$

where $(x_i - \bar{x})$ is the deviation of an attribute for municipality x_i, $w_{ij}$is the spatial weight between municipality i and j, N is equal to the total number of municipalities, and $\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}$ is the aggregate of all the spatial weights. Additional terms are defined as follows:

$$w_{ij} = \frac{c_{ij}}{\sum_{i=1}^{N} c_{ij}} \qquad c_{ij}(i, j = 1,2, \dots, N)$$

where c_{ij} takes a value of one when municipality i and j are contiguous, and a value of zero when two municipalities are not contiguous. The spatial weight matrix W based on k-nearest neighbors, which centroid distances from each municipality i to all municipality j$\neq i$ be ranked as follows: $d_{ij(1)} \leq d_{ij(2)} \leq \dots \leq d_{ij\,(n-1)}$. Then for each $k = 1, \dots, n-1$, the set $N_k(i) = \{j(1), j(2), \dots, j(k)\}$ contains the k closest units to i. In this chapter, the spatial weight matrix W is generated using randomly located coordinates based on each municipality's five nearest neighbors. The reasons for using the spatial weight matrix based on five nearest neighbors is that since the location data of disposal site is based on point data, not polygon data based on actual neighboring relationship between municipalities, we employ the average value of the number of neighboring municipality. In general, a Moran's I value near +1.0 indicates clustering while an index value near −1.0 indicates dispersion, and 0 indicates randomness.

For industrial waste disposal sites in Japan, Moran's I are over 0.191, with a p-value of 0.000 in each year. This suggests that spatial dependency exists within the site location data at the 1% level of statistical significance from 1992 to 2012. Considering these results, aspatial statistical modeling approaches[15] lead to significant model misspecification and biased parameter estimates (Anselin 1988). Figure 4.4 shows the global Moran's I from 1992 to 2012. The Moran's I increased rapidly between 1992 and 1997. After that, it increased slowly, peaking in 2010, while the number of disposal sites decreased. The statistic decreased rapidly in 2012. We find that the value of Moran's I in 2012 is higher than that of 1992, while the number of disposal site in 2012 is a half of that 1992.

Moreover, we calculated the Getis-Ord Gi* statistic (Getis and Ord 1992; Ord and Getis 1995) to detect local patterns of spatial association. The Getis-Ord Gi* statistic is defined as follows:

$$G^* = \frac{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{i,j} x_i x_j}{\sum_{i=1}^{N} \sum_{j=1}^{N} x_i x_j}$$

[15] Aspatial statistical modeling approaches are those that do not consider spatial correlations.

The G^* statistic returned for each municipality is a Z score. A positive and larger value indicates the more intense clustering of high values that means a hot spot. A negative and smaller value indicates the more intense clustering of low values that means a cold spot. The specific test results and a description of the clusters of 1992 and 2012 are presented in Figures 4.5 and 4.6, respectively.

Secondly, we investigate what factors have impact on the location decisions of disposal sites. We estimate a spatial Tobit model to investigate the community characteristics that tend to locate the private industrial waste disposal site in 1992, 2002 and 2012, respectively. In addition, we estimate a spatial auto-regression model to investigate the characteristics of communities where the disposal sites has increased or decreased over 20 years, examining period from 1992 to 2002 and 2002 to 2012. The location data covers 1,693 municipalities in Japan that share a border with at least one other municipality, and this data is aggregated at the municipality level. Municipality-level data provides us detailed information to investigate the decision-making of waste management companies for site location, by considering the characteristics of local communities in proximity to the disposal sites. To analyze the concentration of disposal sites adequately, prefectural-level data is too crude and will not reflect the geographical distribution and their determinants accurately. For instance, prefectural-level data cannot distinguish between a case where all disposal sites are concentrated in a few municipalities of a prefecture and the case where these sites are distributed evenly across all municipalities, even though the total number of disposal sites in a prefecture remains the same. A spatial Tobit model is defined as follows:

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

$$y_i^* = (I_n - \rho W)^{-1} X\beta + (I_n - \rho W)^{-1}\varepsilon$$

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; X is a vector of characteristics describing the site; W is the 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 interdependence induces a truncated multivariate normal distribution (TMVN) for the latent variable thus takes the following form:

$y_i^* \sim TMVN(\mu, \Omega)$
$s.t. \mu = (I_n - \rho W)^{-1} X\beta$
and $\Omega = \sigma_\varepsilon^2 [(I_n - \rho W)'(I_n - \rho W)]^{-1}$

subject to vector of liner inequality restrictions $a \leq y^* \leq b$, where the truncation bounds depend on the observed values of y. 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.

A spatial auto-regression model is defined as follows:

$\Delta y_{i,t} = \rho \boldsymbol{W} \Delta y_{i,t} + \boldsymbol{X}\beta + \varepsilon$
$\varepsilon \sim N(0, \sigma^2 \boldsymbol{I})$
and $\boldsymbol{V} = \sigma^2 [(I_n - \rho W)'(I_n - \rho W)]^{-1}$

where $\Delta y_{i,t}$ is the growth rate of number of disposal sites per 10,000 residents in municipality *i* as of year *t* compared that of twenty years ago, and given by

$$\Delta y_{i,t}\ (\%) = \frac{y_{i,t} - y_{i,t-20}}{y_{i,t-20}} \times 100$$

4.4 Data and Explanatory variables

This chapter draws on a unique data set of the locations of 2,535 private and public industrial waste disposal sites over the period of 1992–2012, collected from all Japanese prefectural governments by request for disclosure. The survey data describes all industrial disposal sites operating from 1992 to 2012. We hypothesize that four factors can influence the location of disposal sites.

Economic factor

The first factor to be considered is the economic factor. Empirical studies suggest that input markets have a significant effect on plant location (Fortenbery et al. 2013). This effect also might be seen in the location of waste disposal sites. In the case of industrial waste, the input for disposal sites is the waste generated by industrial activities. This chapter uses four variables for the economic factor: (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, (3) the total length of highway infrastructure measured at the prefectural level, and (4) the land price measured at the municipal level. The generation of industrial waste captures the supply of waste processed for disposal within the prefecture[16]. The total revenue of production by the local manufacturing sector captures the demand for waste disposal in the municipality. The total length of the prefecture's highways reflects the amount of transportation infrastructure, and a greater length should be associated with lower transportation costs. The land price is a significant part of the fixed cost for the waste management company.

Data on industrial waste generation are drawn from the 1992, 2002 and 2012 Survey on Industrial Waste Emissions and Disposal (Japanese Ministry of the Environment). The data regarding manufacturing production are drawn from the 1992, 2002 and 2012 census of manufacturers (Japanese Ministry of Economy, Trade and Industry). The data regarding the total length of highway infrastructure in each municipality are drawn from the Annual Report of Road Statistics 1992, 2002 and 2012 (Japanese Ministry of Land, Infrastructure, Transport and Tourism). We use the average land price in each municipality, which is reported in the investigation of land prices by prefectural governments (1992, 2000, 2012). The data of land prices are derived from the Geographic Information Systems (GIS) database of the Geospatial Information Authority of Japan.

Existence of other waste-related facilities

The second factor to be considered is the existence of other waste-related facilities. To measure the impact of this factor, three variables are employed: the number of intermediate processing facilities for industrial waste per capita, the number of disposal sites for hazardous

[16] The data on the amount of industrial waste generated and length of highway at the municipality level is unavailable.

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 both unwanted land uses that typically face significant public opposition in their siting decisions. 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 the output of these processing facilities 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 location for such facilities since there might be even stronger opposition from residents than to 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 private industrial waste disposal sites there will be per capita.

The data on intermediate processing facilities are derived from the Survey Report on Administrative Organizations for Industrial Waste by Japanese Ministry of the Environment (1993, 2003, 2013). Location data for hazardous waste facilities was obtained by the request for disclosure. The location data for disposal sites of hazardous waste were gathered from all Japanese prefectural governments by the request for disclosure. 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 privately managed industrial waste disposal within a municipality. To facilitate the disposal of waste, some prefectural and municipal governments 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 the presence of disposal sites operated by the public sector will lead to a lower number of disposal sites by private companies in a municipality. The location data for these public industrial waste disposal sites are also taken from the request for disclosure.

Environmental factor

The environmental factor is the third factor to be considered. This factor plays a significant roll in the location decision of a disposal site. In order to be allowed to begin construction, waste management companies are required to follow environmental assessment procedures. Among the various aspects investigated during this process, we include two representative variables as factors that might strongly affect the location of disposal sites: the prefectural nature reserve dummy variable (1 = the disposal site is located in a prefectural nature conservation area, 0 = other) and 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 the natural environment. The data for nature reserves are based on prefectural nature conservation areas as of 1992, 2002 and 2012 (Japanese Ministry of Environment[17]).

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 Survey on the Usage of Groundwater for Agriculture in 1991, 2003 and 2011 (Japanese Ministry of Agriculture, and Fisheries).

Local community characteristics

The last factor considered is the local community characteristics. Local community characteristics include variables such as the unemployment rate, population density, percentages of agricultural and manufacturing workers, municipal financial stability index, and two population dummy variables (municipality with under 10 thousand people and over 20 thousand people). The unemployment rate captures the environmental justice aspect of disposal sites facility siting. Laurian and Funderburg (2014), who find that towns in France with large vulnerable populations are more likely to host the construction of waste incineration facilities. 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 is simple measure of the NIMBY syndrome, meaning 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

[17] http://www.env.go.jp/park/doc/data/ (Accessed October 5, 2015)

municipality that has such characteristics is more likely to support the location decision. Population dummy variable to test whether the industrial waste disposal site locate in a rural area, urban area or others. Thus, we use two population dummy variables: (1) Rural area dummy (1 = municipality with under 10 thousand people, 0 = others), (2) Urban area[18] dummy (1= municipality with over 20 thousand people, 0 = others). The unemployment, population density, percentages of agricultural and manufacturing workers, and population data are drawn from the 1990, 2000 and 2010 National Census (Japanese Ministry of Internal Affairs and Communications). The municipal financial stability index is drawn from the financial indicators of local governments for 1992, 2002 and 2012 (Japanese Ministry of Internal Affairs and Communications). The summary statistics for all the variables are presented in Table 4.1.

4.5. Results

4.5.1 Location Decisions of Disposal Sites

To compare the factors that have impact on the location decisions of waste disposal sites in 1992, 2002, and 2012, we estimate models that take the number of industrial waste disposal sites per capita in each year as the dependent variable. There is a high correlation between the amount of industrial waste variable and the length of highway infrastructure variable as well as between land price and population density, so we do not include them in the same model. The results of the Bayesian spatial Tobit models are presented in Table 4.2. The spatial parameter ρ is statistically significant in all models estimated using spatial methods. These results indicate that the disposal sites for industrial waste have been spatially concentrated for 20 years. Since the size of coefficients has been decreasing, the concentrations of disposal sites can be interpreted as becoming lower.

The economic factor has a positive effect on location decisions at every point in time. The amount of industrial waste and total revenue from manufacturing production are positive and significant. These results show that the location of industrial waste disposal sites is sensitive

[18] In Japan, local municipality with more than 200,000 inhabitants is defined as a large city.

to the regional demand for waste disposal. The total length of highway infrastructure within a municipality is statistically significant and positive, suggesting the level of infrastructure for transportation might play an important role in determining the locations of disposal sites. This result indicates that the transportation cost from areas where waste is generated to areas where disposal sites are located is an important component of disposal cost. Land price and population density are statistically significant and negative in all the models. These results are plausible, since higher land price and higher population density means higher costs of locating sites.

The number of intermediate processing facilities for industrial waste per capita and the number of hazardous waste disposal sites per capita has positive and statistically significant coefficients in all models. The public site variable is also positive and statistically significant, except for in the 2012 model. It can be presumed that a higher number of waste-related facilities associate with a higher number of industrial waste disposal sites. Not only is the location decisions influenced by economic factors, such as industrial waste outputs and length of infrastructure, but also it is affected by the existence of other waste-related facilities. 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.

For the environmental factor, the level of groundwater usage is statistically significant with negative coefficients in all the models. This result suggests that the municipalities with higher levels of groundwater usage are less likely to be locations for disposal sites. Since higher dependence on groundwater means higher possibility of pollution damage from the site, the negative coefficient of the variable is in line with our expectation.

The unemployment variable is positive but not statistically significant at every point in time, which is not in line with findings of Laurian and Funderburg (2014). The percentage of agricultural workers is also positive and has a statistically significant coefficient in 1992 and 2012, while the percentage of manufacturing workers is negative and has a statistically significant coefficient in 2002. These results indicate that waste management companies tend to locate disposal sites in municipalities with higher populations of agricultural workers. The dummy variable of population under 10 thousand persons is negatively correlated with concentration of disposal sites, while the population over 200 thousand persons dummy variable is positively correlated. It is evident from these results that disposal sites tend to be located in urban areas.

4.5.2 Growth of Spatial Concentrations

In this section, we discuss about the effects of change of the location decisions on concentration of disposal sites. We investigate the characteristics of communities where the number of disposal sites has increased or decreased over 20 years, from 1992 to 2012. The dependent variable is the growth rate of number of industrial waste disposal sites per capita. The results of three periods, from1992 to 2012, from 1992 to 2002, and from 2002 to 2012, estimated by the spatial auto-regression model are presented in Table 4.3. The spatial parameter ρ is statistically significant in all the models. It became clear that there are spatial concentrations of areas where disposal sites are increasing.

The amount of industrial waste and total length of highway infrastructure variables are statistically significant and positive effect on the increasing number of disposal sites, as with the result of previous section. These results supports our hypothesis that the private waste disposal sites relative to its location decision is the potential demand for landfill sites and cost for waste disposal. The demand for waste disposal and transportation cost impact on the profit maximization. Therefore, the higher potential for waste disposal and lower transportation costs there are, the higher increasing the number of private industrial waste disposal sites there will be.

The number of hazardous waste disposal sites per capita is positive and statistically significant in model 2-1 and 2-2, the period from 1992 to 2012. This result means that the existence of hazardous waste disposal sites induce the increasing the number of industrial waste disposal sites 20 years latter. It suggest that waste management companies tend to locate disposal sites in areas in which construction is easier−that is, areas less likely or does not meet with opposition from the inhabitants.

On the other hand, the number of intermediate processing facilities for industrial waste is negative and significant at the 10 % level in the model 2-2. This is in contrast to the result of the previous section, where the intermediate processing facilities associated with higher number of disposal sites. This result means that the large number of the intermediate processing facilities for industrial waste tends to decrease the number of industrial disposal sites. It is consider that the increasing number of the recycle plant included the intermediate processing facilities might decrease the final disposal amount of industrial waste and demand for waste disposal in the long term. The publicly supported disposal sites dummy variable is negative and statistically significant in the 2002–2012 model. It is evident from this result that the location of publicly supported disposal sites leads to decrease in number of private disposal sites in recent 10 years.

The amount of groundwater usage variable is statistically significant and have positive values in the 1992–2012 model. This result is in contrast to the result of the previous section where the level of groundwater usage associated with lower number of disposal sites. These results means that while the municipalities with higher levels of groundwater usage are less likely to be locations for disposal sites, the number of disposal sites increased in areas with higher levels of groundwater usage in the period from 1992 to 2012.

The population rate of manufacturing worker is negative and significant in the 1992–2012 model and in the 1992–2002 model. These results indicate that the increase of disposal sites is founded at municipality with lower population ratio of manufacturing worker. The percentage of agricultural workers is positive and statistically significant in the model for the period from 2002 to 2012, as well as the results of previous section. The population under 10 thousand persons dummy variables is negative and significant in the model for the period from 1992 to 2002. By contrast, the effect is positive and statistically significant in the model from 2002 to 2012. These results indicate that the increase of disposal sites per capita is founded at municipality with lower number of population, but if the number of population rapidly increased in urban area from 2002 to 2012, this hypothesis might not been validated.

4.6 Conclusions

In this chapter we addressed the mechanism behind the locational concentration of private waste disposal sites from a long-term perspective. We investigated the relationship between the locational concentration of disposal sites and the characteristics of local communities over a 20-year period. It is evident from empirical results that there has consistently been a spatial concentration of disposal sites in some areas over 20 years. Moreover, we found that the location decision factors have not changed for 20 years in spite of the number of disposal sites decreasing by half. Economic factors such as input markets and transport infrastructure play a significant role in leading to the location of private disposal sites. These findings suggest that even if the unwanted facility deals with “bads”, the locational concentration of these facilities adapt to the theory of the spatial competition between companies dealing with "goods" (Hoteling 1929).

Our results provide important implications for environmental equity. Waste disposal sites are often unwanted facilities in a local community. Although for location decisions the economic efficiency is a significant factor, this might lead to increasing the unequal distribution of unwanted facilities among local communities. As pointed out by Sasao (2004), a feeling of unfairness at having to treat waste generated by other communities is one reason for residents' opposition to the implementation of policies related to NIMBY. Sasao (2004) indicates that residents in rural areas more strongly oppose accepting waste from other municipalities than those in urban areas, and residents in municipalities with their own landfills more strongly oppose accepting such waste than those in municipalities without them. Frey and Oberholzer-Gee (1996) argue that a fair siting procedure play significant roll to mitigate antipathy, and increase residents' willingness to host an unwanted facility. In this respect, in order to ensure higher regional and environmental equity, it is important to pay attention to the equitable distribution of unwanted facilities such as waste disposal sites. Therefore, it is important to pursue both efficiency and equity in mitigating NIMBY issues.

We further investigated the community characteristics that lead to increase in the number of disposal sites. As a result, it became clear that the regional demand for disposal sites such as the amount of industrial waste impacted location decisions from 1992 to 2002. On the other hand, in the period from 2002–2012 disposal sites tended to be increasingly localized in rural areas where the population is lower and the rate of agricultural workers is higher.

Our results, along with findings from previous studies, suggest that entry of the public sector into the market might mitigate the concentration of unwanted facilities and the residential opposition related to NIMBY. In the growth models, we found that the location of public disposal sites tends to mitigate the concentration of private disposal sites in the long-term. In addition, there has been some discussion about the relationship between the distrust of companies and the reasons for residents' opposition to the construction of unwanted facilities (Ishizaka and Tanaka 2003; Hsu 2006). Even when the required environmental assessment has been completed, some residents are suspicious of the results and of the information provided by private companies. They are skeptical about the safety and efficiency of the disposal methods being employed. Thus, public participation in the siting process should be an important component of information disclosure, as this participatory approach may improve residents' opinions regarding the necessity of the facility, thereby increasing the possibility of acceptance (Lober and Green 1994). In summary, these conclusions offer a suggestion that public management, including sufficient information disclosure and risk communication, might play a significant role in reducing residents' social welfare loss and mitigate the concentrations of unwanted facilities related to the NIMBY issue, higher than privatization in pursuit of economic profits.

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Figure 4.1: The number of operating disposal site

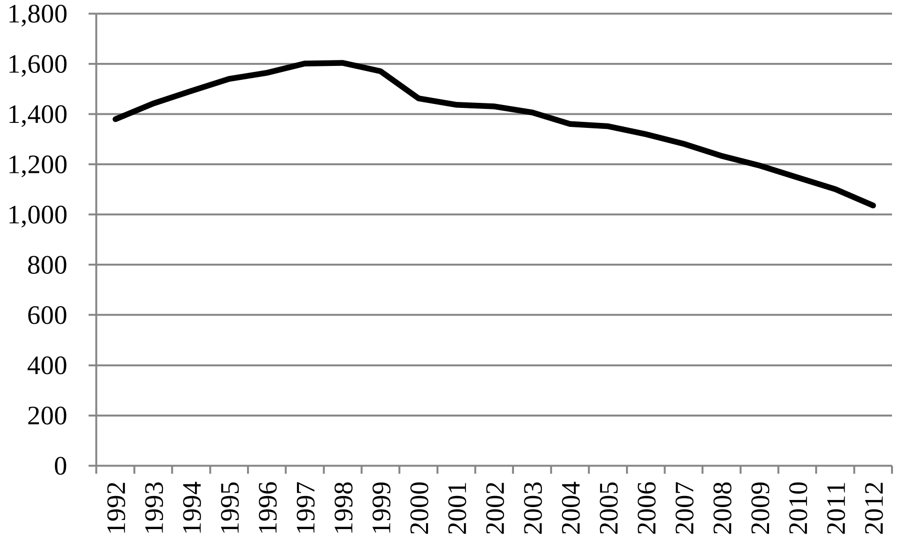

Figure 4.2: The locations of the industrial waste disposal sites in operation of 1992

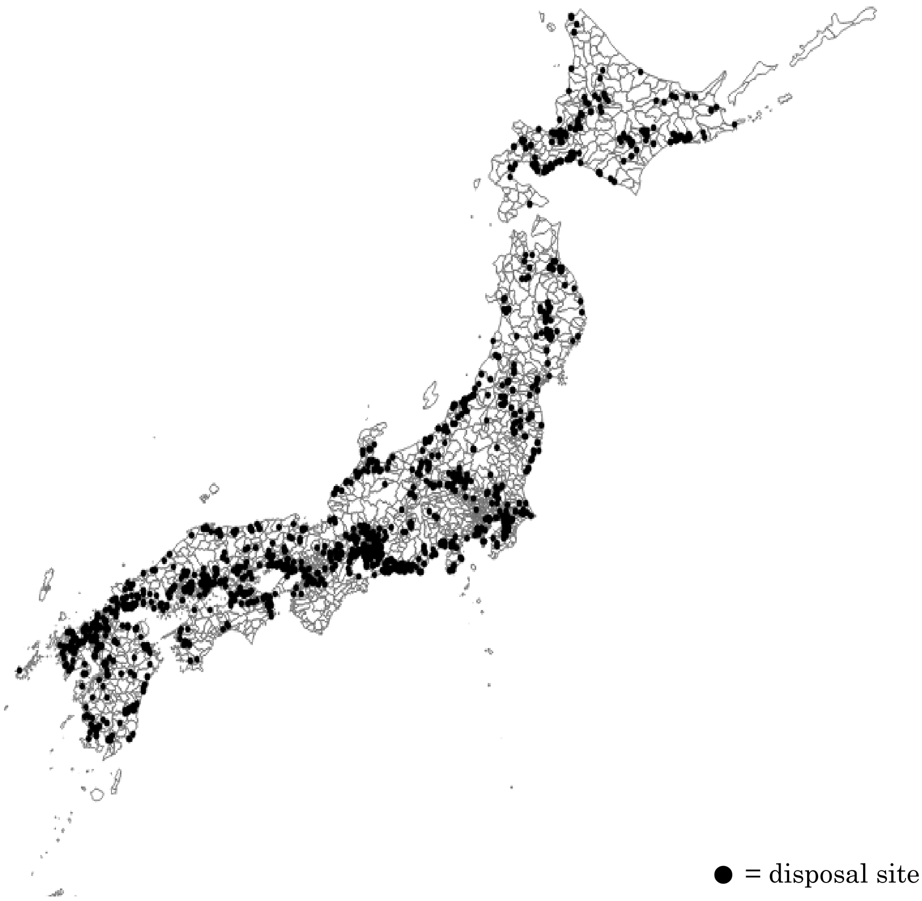

Figure 4.3: The locations of the industrial waste disposal sites in operation of 2012

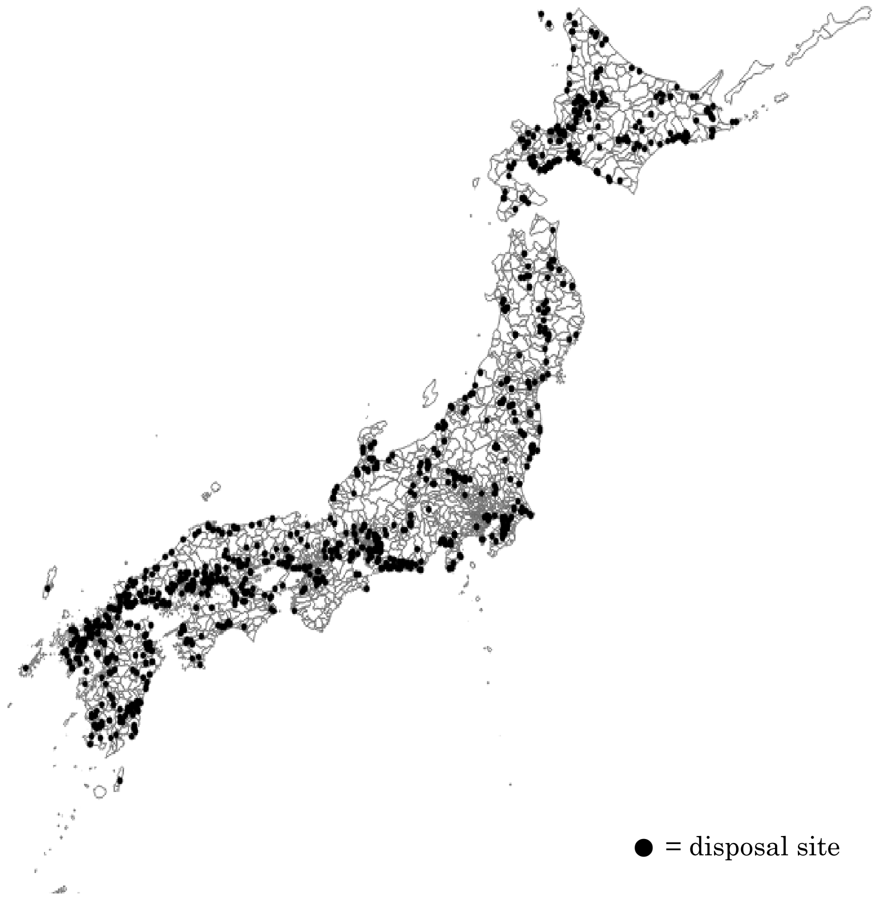

Figure 4.4: Moran's I statistics

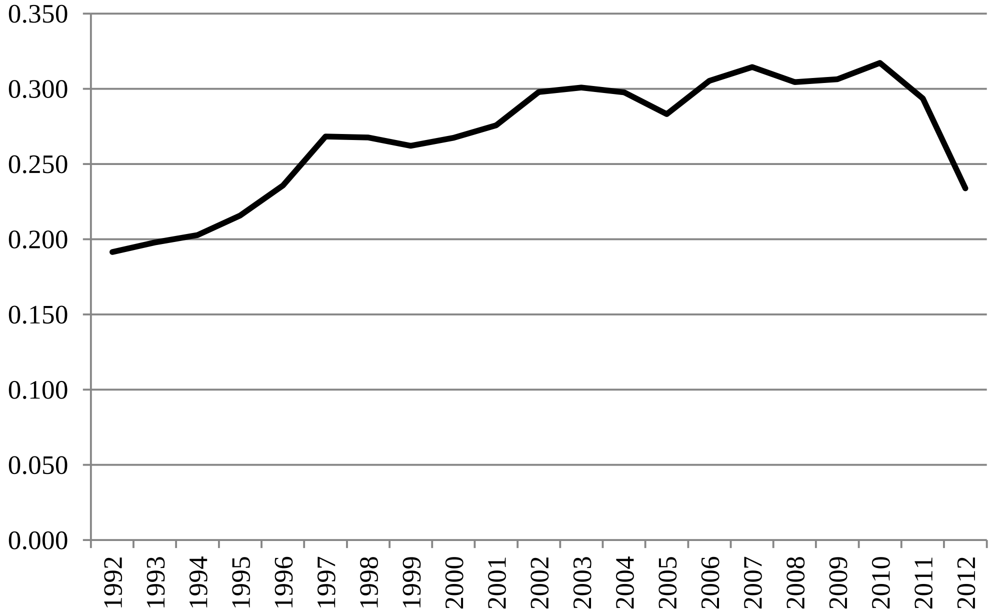

Figure 4.5: Spatial clustering of final disposal sites via Getis–Ord *Gi** of 1992

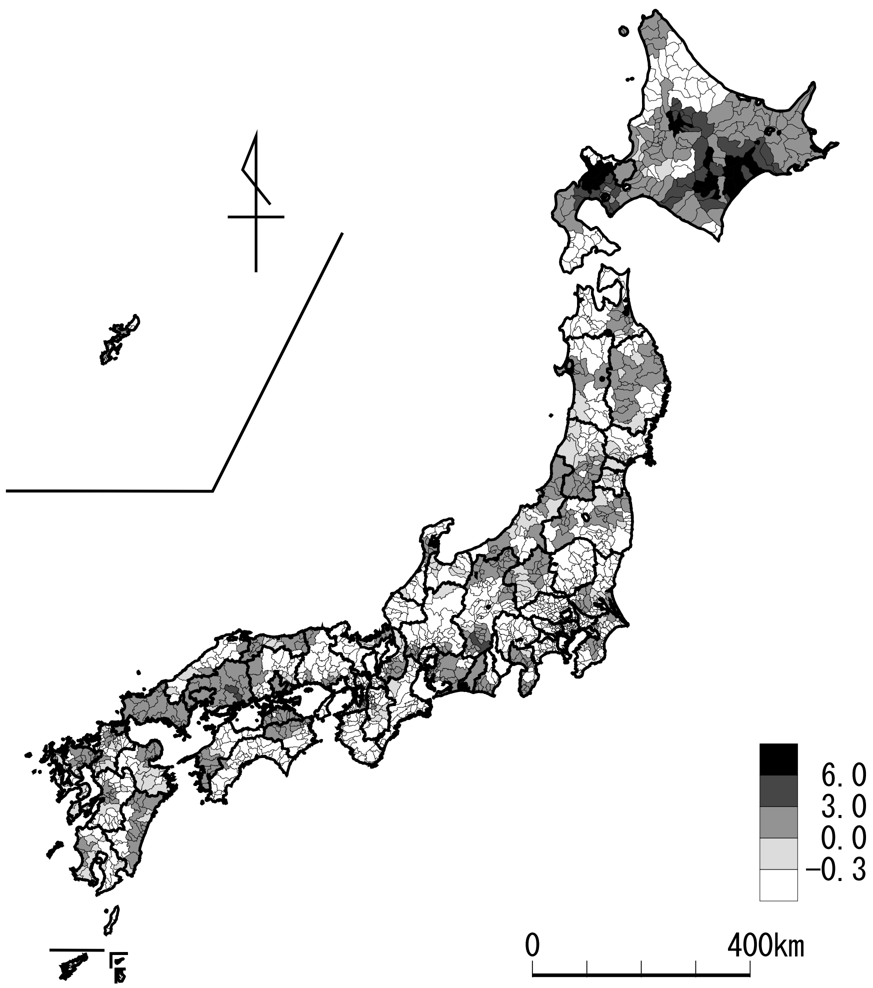

Figure 4.6: Spatial clustering of final disposal sites via Getis–Ord *Gi** of 2012

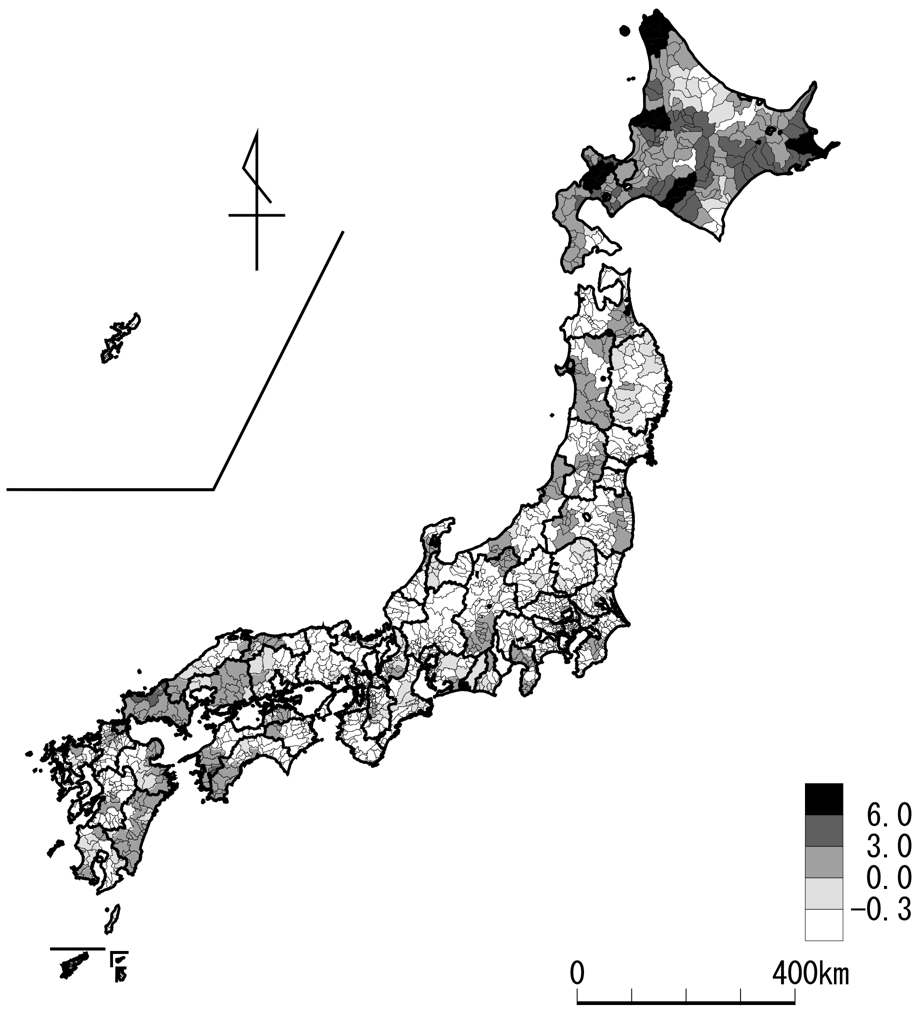

Table 4.1: Descriptive statistics

		1992				2002				2012			
	Unit	Mean	Min	Max	SD	Mean	Min	Max	SD	Mean	Min	Max	SD
Total manufacturing revenue	10 billion yen	19.486	0.000	876.773	51.402	15.901	0.000	984.664	41.282	17.043	0.000	1208.886	48.040
Amount of industrial waste	10 million tons	1.197	0.176	3.303	0.975	1.223	0.151	4.020	1.136	1.162	0.113	3.612	1.022
Land price	10,000 yen	13.902	0.178	1325.364	61.896	8.003	0.000	484.580	18.787	6.111	0.162	546.700	22.711
Length of highway infrastructure	100 km	1.744	0.182	4.804	1.293	1.716	0.182	4.081	1.161	2.243	0.182	6.859	1.799
Disposal site for hazardous waste	sites/10,000 persons	0.006	0.000	1.331	0.060	0.007	0.000	1.431	0.072	0.022	0.000	8.032	0.260
Intermediate site for industrial waste	sites/10,000 persons	0.964	0.126	2.455	0.510	1.781	0.278	3.703	0.712	1.886	0.229	4.793	0.864
Publicly supported disposal site	1 = yes, 0 = otherwise	0.044	0.000	1.000	0.206	0.057	0.000	1.000	0.231	0.046	0.000	1.000	0.210
Nature reserve	1 = yes, 0 = otherwise	0.193	0.000	1.000	0.395	0.196	0.000	1.000	0.397	0.203	0.000	1.000	0.402
Amount of groundwater	million m^3	79.086	1.664	1187.112	153.162	70.596	1.179	771.413	114.522	62.198	2.098	690.866	102.038
Population density	person /100km^2	13.189	0.018	221.484	25.280	10.879	0.019	198.541	23.083	10.751	0.016	218.815	24.685
Unemployment	%	2.632	0.000	14.201	1.424	3.010	0.052	358.629	10.406	6.326	0.000	22.718	2.124
Agricultural workers	%	7.713	0.012	46.652	6.692	5.637	0.000	48.932	5.616	4.940	0.000	52.333	5.187
Manufacturing workers	%	11.703	0.578	32.275	5.432	9.790	0.347	29.959	4.827	8.131	0.492	23.831	4.094
Municipal financial stability index	point	0.493	0.060	2.230	0.323	0.489	0.070	2.250	0.292	0.500	0.070	2.130	0.282
Population under 10,000	1 = yes, 0 = otherwise	0.231	0.000	1.000	0.422	0.241	0.000	1.000	0.428	0.241	0.000	1.000	0.428
Population over 200,000	1 = yes, 0 = otherwise	0.073	0.000	1.000	0.261	0.077	0.000	1.000	0.267	0.077	0.000	1.000	0.267

Table 4.2: Estimation results (Dependent variable: the number of disposal sites for industrial waste per capita)

	1992		2002		2012	
	Model 1-1	Model 1-2	Model 1-3	Model 1-4	Model 1-5	Model 1-6
Disposal site for hazardous waste	1.562***	1.400**	1.863***	1.696***	0.408**	0.402**
	(0.580)	(0.583)	(0.591)	(0.648)	(0.174)	(0.174)
Intermediate site for industrial waste	0.303***	0.240**	0.364***	0.321***	0.297***	0.294***
	(0.094)	(0.093)	(0.094)	(0.090)	(0.085)	(0.080)
Publicly supported disposal site	0.411**	0.367**	0.298	0.394*	0.317	0.361
	(0.198)	(0.183)	(0.216)	(0.214)	(0.234)	(0.238)
Nature reserve	0.000	-0.014	-0.164	-0.123	-0.194	-0.104
	(0.109)	(0.1085)	(0.142)	(0.150)	(0.149)	(0.147)
Amount of groundwater	-0.001***	-0.001***	-0.001**	-0.001*	-0.002**	-0.001**
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Unemployment	-0.011	-0.008	0.002	0.003	-0.012	-0.016
	(0.039)	(0.037)	(0.006)	(0.006)	(0.031)	(0.033)
Agricultural workers	0.018*	0.017*	0.016	0.013	0.032**	0.031*
	(0.010)	(0.010)	(0.012)	(0.013)	(0.016)	(0.017)
Manufacturing workers	-0.013	-0.017	-0.028**	-0.057***	-0.008	-0.027
	(0.011)	(0.011)	(0.014)	(0.013)	(0.017)	(0.017)
Municipal financial stability index	0.140	0.419**	0.260	0.376	0.389	0.275
	(0.190)	(0.187)	(0.260)	(0.256)	(0.313)	(0.330)
Population under 10,000	-0.917***	-0.902***	-1.116***	-1.160***	-1.037***	-1.126***
	(0.144)	(0.144)	(0.178)	(0.182)	(0.189)	(0.188)
Population over 200,000	0.664***	0.448**	0.605**	0.475*	1.069***	0.783***
	(0.212)	(0.196)	(0.255)	(0.268)	(0.263)	(0.270)
Total manufacturing revenue	0.002*	0.002**	0.004***	0.005***	0.002*	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Amount of industrial waste	0.136***		0.367***		0.381***	
	(0.050)		(0.049)		(0.056)	
Population density	-0.017***		-0.035***		-0.041***	
	(0.003)		(0.006)		(0.007)	
Length of highway infrastructure		0.185***		0.281***		0.210***
		(0.034)		(0.046)		(0.032)
Land price		-0.018***		-0.055***		-0.055***
		(0.005)		(0.013)		(0.016)
ρ	0.382***	0.319***	0.292***	0.335***	0.243***	0.265***
	(0.045)	(0.045)	(0.048)	(0.047)	(0.051)	(0.055)
σ^2	1.875***	1.716***	2.851***	3.012***	2.863***	2.930***
	(0.168)	(0.144)	(0.226)	(0.259)	(0.264)	(0.275)
Intercept	-0.804**	-1.027***	-1.427***	-1.084***	-1.801***	-1.652***
	(0.312)	(0.300)	(0.308)	(0.299)	(0.464)	(0.487)
Observations	1,693	1,693	1,693	1,693	1,693	1,693

Note: Standard errors are given in parentheses. * p< 0.10; ** p < 0.05; *** p < 0.01.

Table 4.3: Estimation results (Dependent variable: the growth rate of number of disposal sites for industrial waste per capita)

	Period from 1992 to 2012		Period from 1992 to 2002		Period from 2002 to 2012	
	Model 2-1	Model 2-2	Model 2-3	Model 2-4	Model 2-5	Model 2-6
Disposal site for hazardous waste	60.444 **	58.941 **	22.732	21.418	-8.766	-9.086
	(23.526)	(23.526)	(23.020)	(23.016)	(10.673)	(10.676)
Intermediate site for industrial waste	-5.104	-6.012 *	-5.551 *	-5.606 *	-1.104	-1.445
	(3.164)	(3.048)	(3.096)	(2.981)	(1.292)	(1.247)
Publicly supported disposal site	2.519	3.045	4.254	5.163	-6.709 *	-6.768 *
	(7.248)	(7.229)	(7.093)	(7.072)	(3.476)	(3.467)
Nature reserve	-5.398	-4.979	-4.644	-3.631	-0.196	-0.587
	(3.624)	(3.612)	(3.546)	(3.534)	(1.973)	(1.951)
Amount of groundwater	0.027 ***	0.027 ***	0.028 ***	0.030 ***	0.006	0.005
	(0.009)	(0.009)	(0.009)	(0.009)	(0.007)	(0.007)
Unemployment	-0.182	-0.191	-0.731	-0.584	0.021	0.024
	(1.258)	(1.270)	(1.231)	(1.243)	(0.074)	(0.074)
Agricultural workers	0.103	0.073	-0.310	-0.302	0.357 **	0.346 **
	(0.322)	(0.321)	(0.316)	(0.314)	(0.174)	(0.174)
Manufacturing workers	-0.695 **	-0.771 **	-1.014 ***	-1.083 ***	0.113	0.102
	(0.344)	(0.341)	(0.337)	(0.334)	(0.190)	(0.184)
Municipal financial stability index	-12.743 **	-10.721	-14.265 **	-13.511 **	-0.844	-0.313
	(6.188)	(6.062)	(6.052)	(5.928)	(3.448)	(3.427)
Population under 10,000	-5.712	-5.656	-12.208 ***	-12.203 ***	3.853 *	4.001 *
	(3.892)	(3.894)	(3.809)	(3.811)	(2.097)	(2.107)
Population over 200,000	-0.983	-4.306	2.524	-4.488	0.546	1.982
	(7.130)	(6.708)	(6.977)	(6.563)	(3.692)	(3.497)
Total manufacturing revenue	-0.026	-0.026	0.028	0.026	-0.070 ***	-0.070 ***
	(0.036)	(0.036)	(0.035)	(0.035)	(0.023)	(0.023)
Amount of industrial waste	3.948 **		3.906 **		0.125	
	(1.663)		(1.628)		(0.728)	
Population density	-0.105		-0.235 ***		0.065	
	(0.074)		(0.072)		(0.045)	
Length of highway infrastructure		2.685 **		4.017 ***		-0.552
		(1.188)		(1.168)		(0.718)
Land price		0.003		-0.020		0.033
		(0.024)		(0.024)		(0.045)
ρ	0.073 *	0.072 *	0.106 ***	0.098 **	0.111 ***	0.110 ***
	(0.039)	(0.039)	(0.038)	(0.038)	(0.038)	(0.038)
Intercept	15.369	15.125	33.649 ***	28.781 ***	-6.719 *	-4.668
	(10.046)	(10.068)	(9.848)	(9.860)	(3.936)	(3.647)
Observations	1,693	1,693	1,693	1,693	1,693	1,693

Note: Standard errors are given in parentheses. * p< 0.10; ** p < 0.05; *** p < 0.01.

Chapter 5

Conclusion

This study has investigated why NIMBY occurs and how we can mitigate it. Our conclusions can be summarized as follows. Firstly, inadequate risk communication exacerbates NIMBY issues. In Chapter 2, we investigated the determinants for the municipalities' acceptance of disaster waste resulting from the Great East Japan Earthquake. As a result, we found that municipalities with a larger share of agricultural workers and longer distance from the affected area tended to refuse disaster waste from the affected areas, but at the same time wished them a quick recovery from the earthquake damage. In these municipalities, due to less knowledge and information of risk, residents feared that acceptance of tsunami waste could create a negative image of their agricultural products by rumors of pollution. This conclusion is also supported by the results in Chapter 3 that investigated the community characteristics where conflict with residents over construction of disposal sites is likely to take place. It is evident from Chapter 3 that conflict with residents is likely to take place in areas where there is higher possibility of receiving environmental or economic damage from the inappropriate operation of disposal sites, such as in areas where dependence on the use of groundwater is higher. These results show that the opposition, to some extent, comes from the residents' anxiety over risk stemming from the policy implementation. Information disclosure and risk communication are important to implement policy related to NIMBY problems, especially for municipalities that are susceptible to external diseconomy.

Secondly, social preference might play a role in mitigation of NIMBY. In Chapter 2, we focused on the role of social factors such as altruism, measured as the amount of donations to disaster victims, and reciprocity, i.e. if accepting municipalities themselves face risk of a similar situation. It is extremely important not to ignore such psychological aspects in regard to the NIMBY issue. The results indicate that social preferences are a more important factor for decision to acceptance of disaster waste, than economic reasons. This may suggest that understanding how pro-social behavior can positively affect cooperation is important for policy interventions on NIMBY problems and support feelings of YIMBY (yes in my backyard). Furthermore, it would also be helpful for the ministry in the central government to understand when it comes to coordinating the decision making of municipalities in different areas and at different levels.

Thirdly, it is important to pay attention to the equitable distribution of unwanted facilities such as waste disposal sites. The results from Chapter 4 indicate that there has been a spatial concentration of disposal sites over the last two decades to areas with other waste-related facilities, large input markets, and transport infrastructure, while the total number of disposal sites decreased by half during this period. Thus, more attention should be paid to the fact that the pursuit of efficiency in location decisions of disposal sites causes the inequitable distribution of unwanted facilities. In this connection, in Chapter 4, we also found that municipalities with publicly supported disposal sites tend to decrease the number of private disposal sites in the following 10 years. In this respect, in the long run the development of publicly supported disposal sites might lead to a decrease in the number of private disposal sites.