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Abstract

This study investigates whether municipal mergers promote waste recycling and generate lower waste. Using difference-in-differences with matching, we estimate the effect of the large-scale consolidation in Japan on waste management, waste generation, and collection of recyclable plastics. We find merged municipalities are less likely to adopt unit pricing of household waste which might explain higher waste generation in the merged municipalities. Our results also show that the amount of recycled PET bottles is lower in the merged municipalities. These results suggest that municipal mergers indeed have an impact on municipal solid waste management but may not lead to more strict waste management and lower waste generation.

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1 Introduction

Waste is produced every day, everywhere in the world. The World Bank Group estimates that the world generates 2 billion tons of municipal solid waste annually and expects that volume to grow to 3.4 billion tons by 2050 (Kaza et al., 2018). As a result, there are great concerns about how to deal with those wastes, in an efficient manner. Because municipal solid waste management has been a major challenge for cities in search of sustainable development, it is imperative to explore how municipal institution matters for waste management.

Municipal merger reforms have been deployed by many industrialized countries in the belief that larger municipal units can increase efficiency in public service provision in recent decades (Fox and Gurley, 2006; Blesse and Baskaran, 2016). Japan's Great Heisei Consolidation which reduced about 45% of its municipalities offers a good example for studying the reform's impact in a country with limited financial resources for local governance. While the impact of the Heisei Consolidation has been investigated elsewhere, for example, the fiscal common pool problem (Hirota and Yunoue, 2017), less attention has been paid to the impact on their waste management despite the importance for local governments.

Municipal mergers can variously affect waste management. First, it might lead to the reduction of the genral fiscal cost through the scale economy (Blom-Hansen et al., 2014; Reingewertz, 2012). Second, it provides an opportunity to revise policies regarding waste management, such as unit pricing of waste and the number of items for the collection of recyclables. In this study, we mostly focus on the second channel and explore if the Heisei Consolidation contributed to the reform of waste management and thereby to the reduction of waste.

This study investigates whether municipal mergers improve their solid waste management, reduce the generation of waste, and promote the recycling of waste. We exploit the

Great Heisei Consolidation in Japan as a natural experiment and employ the difference-in-differences (DID) method with Mahalanobis matching to estimate the impacts. The Japanese Ministry of the Environment provides a detailed database on municipal solid waste management that allows us to implement an analysis over ten years that covers the merger periods.

The estimation results of this study indicate that the Heisei Consolidation may not contribute to reducing the amount of waste and little contributes to promoting recycling. We first document that the consolidation has a negative impact on the implementation of the unit-pricing on municipal solid waste. The treatment group did not actively adopt the unit-pricing programs after the municipal mergers. The reluctance to adopt the economic instruments may play a role in increased waste in these municipalities. Indeed, our estimation results also suggest an increase in total municipal solid waste generation by 8.6 kg per capita annually in the merged municipalities. Furthermore, municipal mergers could result in a lower amount of recycled PET bottles.

The contributions of our study can be summarised as follows. First, we are one of the first to apply the DID method to the effect of mergers on municipal waste management as far as we know. Among the existing literature, few focus on the effect of municipal mergers on waste management. Shimamoto (2019) examines the factors that impact municipal solid waste per capita and the recycling rate at the prefecture level in Japan. The author found that the female population and senior citizen population tend to have a lower waste per capita while higher gross domestic product and higher educational attainment result in a higher waste per capita. As the author studied at the prefecture level, the effect of municipal mergers is not examined. Chifari et al. (2017) analyzed Japanese municipal waste management and estimated the cost elasticity with respect to the waste volumes at three treatment stages: collection, processing, and disposal. They observed economies of scale at all three stages. As they only used the dataset of 2010, they could not capture the effect of the Great Heisei Consolidation as well. Tsuzuki et al. (2018) considered the effect of municipal mergers when studying unit-based pricing by adding a dummy variable to capture the effect. They actually found that the Great Heisei Consolidation might increase waste generation but they were not able to give a detailed reason for it.

The second contribution is that we provide a piece of empirical evidence on the relationship between the municipal merger and the unit-pricing of municipal solid waste. Although many studies have investigated the impact of the pricing on waste generation and recycling (Valente, 2023; Bueno and Valente, 2019; Bel and Gradus, 2016), none have investigated how the adoption of the program is affected by the national reform of municipal structure. Our empirical estimates add unique insights to the literature on the impact of economic instruments on waste management.

The remainder of this study is organized as follows. Section 2 introduces the background of our study. Section 3 explains the dataset and models used in our analyses. Section 4 presents and discusses our empirical results. Section 5 concludes.

2 Background

2.1 The Great Heisei Consolidation in Japan

The Great Heisei Consolidation formally started in 1999 with the enforcement of the Special Municipal Mergers Law. The mergers were expected to strengthen the administrative and financial foundation of municipalities, enable more efficient municipal administration, and meet the needs of residents (Yokomichi, 2017). The Special Municipal Mergers Law adopts a carrot-and-stick approach. If municipalities chose not to merge, they would face reductions in certain grants, whereas merged municipalities would maintain their grants for at least 10 years and be permitted to issue special bonds for new public projects, 70% of which would be covered by the central government (Hirota and Yunoue, 2017).

The Great Heisei Consolidation can be divided into two stages. The first stage is from 1999 to 2006 while the second stage is from 2007 to 2010. The main difference between the first and second stages is that the municipalities merged in the first stage will receive larger fiscal measures than the second stage. Therefore, most of the municipalities merged in the first stage. The number of municipalities in Japan reduced from 3,229 in 1999 to 1,821 in 2006 when the first stage ended and to 1,727 when the second stage finished in 2010. Types of these mergers can also be divided into two: absorptions, in which a large municipality absorbs a smaller one or several smaller ones, and fusions, in which a new municipality is created by the consolidation of several municipalities. The fusion comprises approximately 85% of the mergers realized during the Great Heisei Consolidation.

Before the actual implementation of municipal mergers, the municipalities that were going to merge together would organize a consolidation conference or council to discuss the details of the municipal merger. According to the Ministry of Internal Affairs and Communications of Japan (2005), the average duration between the establishment of the consolidation conference is about eighteen months. As there are negotiation and coordination in order to deal with the difficulties and achieve their common goals, there could be an impact on the waste management policies in the newly formed municipalities.

2.2 Municipal Solid Waste Management in Japan

Japan has been implementing policies for promoting the 3Rs (Reduce, Reuse, Recycle) and investing vast resources in recycling due to its limited land area. In the fiscal year 2019, Japan spent 2,089 billion yen on processing 42.7 million tons of municipal solid waste. There are a series of laws enacted to reduce waste generation and promote recycling, such as the Container and Packaging Recycling Law in 1995, the Home Appliance Recycling Law in 1998, the Basic Law for Establishing a Circular Society in 2000, and the End-of-life Vehicle Recycling Law in 2002 (Honma and Hu, 2021).

Local municipalities are responsible for the management of solid waste and determine policies and rules based on a series of waste management laws. Therefore, there is a considerable variation in rules for waste disposal depending on the municipality where one lives. For example, one municipality could have different items of waste separations from another one. Furthermore, many municipalities charge for the disposal of certain kinds of waste through unit-based pricing to reduce waste generation and ease the financial burden.

Municipalities have to make a choice regarding waste management policies when they plan to merge with other municipalities. They must have unified policies for the newly formed municipalities. Regardless whether they decide to follow existing policies from some of the merging municipalities or make completely new waste management policies, the merger provides an opportunity to revise the waste management policies. The coordination and negotiation during the consolidation conferences and the scale of the new municipalities will play a key role in their decision-making.

3 Data and Methodology

3.1 Data

We obtain most of our data from the Annual Survey of Municipal Solid Waste (Ministry of the Environment of Japan, 2022). This survey covers all municipalities in Japan and includes detailed information on municipal solid waste management such as the amounts of various kinds of waste items, the population involved, the charging policy for various waste, and the number of waste separations. Because of data availability and integrity, we exclude some municipalities such as Tokyo Special Wards, municipalities that suffered from large-scale disasters such as the Great East Japan Earthquake, and those with corrupted data. We should also note that there are some municipalities with very large annual changes in the amount of waste generation per capita. To avoid the effect of the extreme values, we exclude municipalities that ever had an annual change over $\pm 50\%$, which amounts to about 10% of all the municipalities in Japan.

We also obtain data on changes to the municipal codes from the Portal Site of the Official Statistics of Japan (Ministry of Internal Affairs and Communications of Japan, 2022) and manually merge the data into the waste management dataset. We use municipalities that merged in 2004 and 2005 as the treatment group and those that did not merge between 1999 and 2018 as the control group.[1] Approximately 85% of the mergers were carried out in 2004 and 2005, given the strong fiscal measures from the central government during the first stage of the Consolidation as described in the previous section.[2]

In addition to the waste management and the municipal merger datasets, we also collect data on municipality characteristics from the Portal Site of the Official Statistics of Japan (Ministry of Internal Affairs and Communications of Japan, 2022). This dataset contains the variables we used for matching, including area, population, population over 65 years old, the net balance of settled accounts, financial capability index, taxable income, sales for the agriculture sector, sales for the manufacturing sector, and sales for the commercial sector. Owing to data availability, all of these variables are averages during a ten-year period before our research period. The net balance of settled accounts, financial capability index, taxable income, and sales for the agriculture sector are the averages from 1989 to 1998. Population, population over 65 years old, are the averages of 1990 and 1995. Sales for the manufacturing sector is the average of 1997 and 1998. Sales for the commercial sector is the average of 1990 and 1998.

One of the biggest difficulties in this research is how to handle municipal mergers in the data set compilation. Here, we process the dataset based on the post-merger level and take the municipality structure after mergers as the baseline of the data aggregation. In this regard, the number of municipalities is the same between before and after the mergers. Therefore, we aggregate data before mergers as if they already merged during the pre-merger period. For dummy variables and count variables, we take their average and use fractional values.

Table 1 reports the descriptive statistics of the baseline model. There are 1,305 municipalities in the dataset and the research period is twenty years. The average annual waste

[1]We exclude municipalities that merged in other years and those that merged two or more times from the sample.

[2]We refer to the fiscal year when the municipal code in the Annual Survey of Municipal Solid Waste changes as the year they merged.

per capita is approximately 326 kg in the treatment group and 342 kg in the control group. The average number of waste separations is 10.164 items in the treatment group and 9.821 items in the control group.

We should note the following regarding the data compilation process. First, we calculate the total waste by adding the waste collected by municipalities and recyclables collected by civil groups. We also calculate the household waste by adding the household waste collected by municipalities and recyclables collected by civil groups. We then divide these amounts by the population to calculate the waste per capita. Second, the indicators for waste management policies such as charging and collecting are fractional dummy variables. They take the value of one, zero, or fractional values in the pre-merger periods. Third, as there is a data limitation on the number of waste separations in the early research periods,[3] we exclude several municipalities from the dataset. As a result, the sample size of waste separation analysis is smaller than other variables in the dataset. Last, the amount of recycled plastic container waste we referred to in this study includes not only plastic containers but also white trays and other plastic wastes.

[3]For example, if the municipalities had more than ten waste separation items, the data was recorded as "Above 11 items" and the exact separation items was not available.

Table 1: Descriptive Statistics

Variable	Obs.	Mean	Min	Max	Std. Dev.
All					
Unit-pricing on Combustible Waste (*dummy*)	26,100	0.526	0	1	0.494
Unit-pricing on Incombustible Waste (*dummy*)	26,100	0.395	0	1	0.484
Number of Waste Separations (*numeral*)	15,680	9.894	1	27	4.244
Annual Total Waste Per Capita (*ton*)	26,100	0.338	0.090	2.960	0.100
Annual Household Waste Per Capita (*ton*)	26,100	0.255	0.082	0.902	0.060
Annual Collection of PET Bottles Per Capita (*ton*)	26,100	0.002	0	0.038	0.001
Annual Collection of Plastic Container Per Capita (*ton*)	26,100	0.004	0	0.083	0.006
Treatment Group					
Unit-pricing on Combustible Waste (*dummy*)	7,060	0.611	0	1	0.468
Unit-pricing on Incombustible Waste (*dummy*)	7,060	0.413	0	1	0.472
Number of Waste Separations (*numeral*)	3,340	10.164	2	24	4.183
Annual Total Waste Per Capita (*ton*)	7,060	0.326	0.130	1.041	0.074
Annual Household Waste Per Capita (*ton*)	7,060	0.244	0.090	0.659	0.050
Annual Collection of PET Bottles Per Capita (*ton*)	7,060	0.002	0	0.035	0.001
Annual Collection of Plastic Container Per Capita(*ton*)	7,060	0.003	0	0.083	0.006
Control Group					
Unit-pricing on Combustible Waste (*dummy*)	19,040	0.494	0	1	0.500
Unit-pricing on Incombustible Waste (*dummy*)	19,040	0.389	0	1	0.487
Number of Waste Separation Sorts (*numeral*)	12,340	9.821	1	27	4.258
Annual Waste Per Capita (*ton*)	19,040	0.342	0.090	2.960	0.108
Annual Household Waste Per Capita (*ton*)	19,040	0.260	0.082	0.902	0.063
Annual Collection of PET Bottles Per Capita (*ton*)	19,040	0.002	0	0.038	0.001
Annual Collection of Plastic Container Per Capita (*ton*)	19,040	0.004	0	0.060	0.005

3.2 Differences-in-Differences Design

We adopt a Differences-in-Differences design (Meyer, 1995) to address the endogeneity of merger decisions. As we focus on municipal mergers in 2004 and 2005, we employ the DID design with two different treatment timings. We assume the treatment effect is identical in these two years because both two years are in the same stage of the Great Heisei Consolidation. The baseline model can be expressed as follows:

$$Y_{it} = \alpha_i + \gamma_t + \beta DiD_{it} + X_{jt} + \epsilon_{it} \tag{1}$$

The variable Y_{it} denotes the outcome variables. DiD_{it} is a dummy variable that captures the treatment effect of municipality i in year t. It will take one for treated municipalities in the post-merger periods and zero otherwise. Moreover, year fixed effects γ_t and municipality fixed effects α_i are included in the model to control for the time-invariant characteristics of common time effects and given municipalities. X_{jt} denotes the control variables at the prefecture level. As previous studies (Usui et al., 2015; Ishimura, 2022) suggest that the decision-making on municipal waste management policies could be affected by the neighboring municipalities, we include the mean value of the municipal policy indicators of the same prefecture j in the year t as the control variable. Therefore, $Control_c$, $Control_i$, and $Control_s$ represent the prefecture average of the implementation status of the unit-pricing program on combustible waste (c), incombustible waste (i), and the number of waste separation (s). ϵ_{it} is the error term. Standard errors are clustered at the municipality level.

In addition to the estimation using OLS, we also use the General Linear Model (GLM) method as the robustness check as we have dummy outcome variables. Our dataset, however, is a fractional one resulting from the way we handle the municipal merger data which causes difficulties when estimating them using the conventional Probit model. To solve this problem, we follow Papke and Wooldridge (1996) to employ a fractional Probit regression by the generalized linear model using the Probit link function as the alternative method.

3.3 Event Study

The common trend or parallel trend assumption is one of the most important assumptions of the DID model. To examine the validity of the parallel trend assumption and provide analyses of the time effect, we adjust our main model to implement an event study using the following OLS model:

$$Y_{it} = \alpha_i + \gamma_t + \sum_{p=-5}^{-2} \beta_p treat_i * T_p + \sum_{q=0}^{13} \beta_q treat_i * T_q + X_{jt} + \epsilon_{it}, \tag{2}$$

where *treat* is a dummy variable that equals 1 when the observation is in the treatment group, T_p is a dummy variable for p years before the merger, and T_q is a dummy variable for q years after the merger. More concretely, T_{-5} indicates the year 1999 for those merged in 2004 and the year 2000 for those merged in 2005. T_{13} indicates the year 2017 for those merged in 2004 and the year 2018 for those merged in 2005. The event study covers all lengths of our research period and the reference group is one year before the merger, which is 2003 for those merged in 2004 or 2004 for those merged in 2005. Municipality fixed effect α_i and year fixed effect γ_t are included similarly to the baseline model.

3.4 Mahalanobis Distance Matching

To reduce sample selection bias, we use the Mahalanobis distance matching method. Although propensity score matching (PSM) is widely used to match the observations treatment and control groups by their predicted probabilities of being treated (Rosenbaum and Rubin, 1983), there are concerns that propensity score matching might not be the most optimized matching method (King and Nielsen, 2019).

The Mahalanobis distance between two units is determined by the difference in the values of the covariates of these two units. Therefore, we can rely on the Mahalanobis distance to find proper pairs from the control group and treatment group. We choose seven covariates to perform the matching following Li and Takeuchi (2023): area, population, the percentage of the population over 65 years old, net balance of settled accounts, taxable income per capita, sales for the agriculture sector, and sales for the manufacturing sector. The descriptive statistics of the dataset used for matching are reported in Appendix Table A.1.

We use the Sata package kmatch (Jann, 2017) to perform the MDM. Epanechnikov kernel function (Epanechnikov, 1969), which has a simple quadratic form and is commonly used to produce weights in matching, is used in this process. The optimized bandwidth generated by the Stata function kmatch by default configuration is 2.829 and the balancing plot of the MDM is shown in Figure 1 of the main dataset. A similar process is also carried out for the waste separation sort dataset. We use the matching weight generated by the MDM to perform the weighted DID regression and event study.

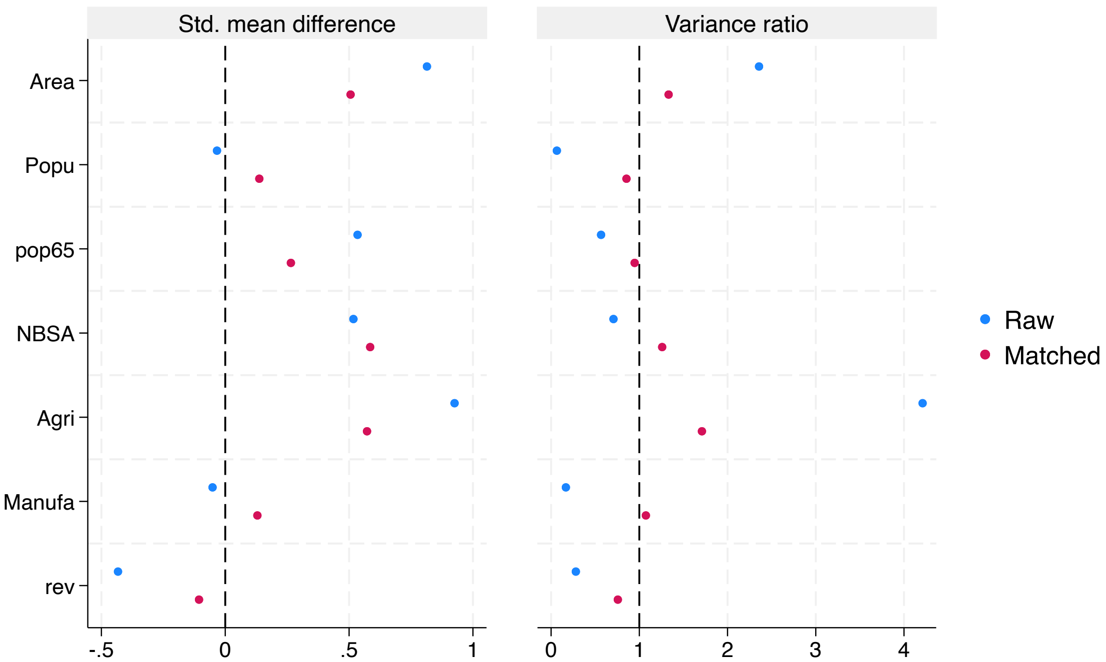

Figure 1: Balancing Plot of the Mahalanobis Distance Matching

4 Results and Discussion

4.1 Waste Management Policies

One of the direct effects of municipal mergers could be the change in municipal waste management policies. Therefore, we begin by focusing on the unit pricing of combustible and incombustible waste, as well as the number of separation categories sorts as these policies affect the household behavior regarding waste disposal. Table 2 reports the results of the estimation of the municipal mergers' effect on waste management policies.

Table 2: The Effect of Municipal Mergers on Charging Policies

	(1) UP Combustible	(2) UP Incombustible	(3) # Separation
DiD	-0.036*	-0.045**	0.368
	(0.020)	(0.023)	(0.256)
$Control_c$	1.032***		
	(0.065)		
$Control_j$		1.052***	
		(0.071)	
$Control_s$			0.904***
			(0.0620)
Municipal FE	YES	YES	YES
Year FE	YES	YES	YES
Treatment Group	353	353	167
Control Group	952	952	617
Observations	26,100	26,100	15,680

Notes: Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$ $Control_c$, $Control_i$, and $Control_s$ represent the prefecture average of the implementation status of the unit-pricing program on combustible waste (c), incombustible waste (i), and the number of waste separation (s), respectively.

The estimation results show statistically significant and negative coefficients for the charging policy for both combustible waste and incombustible waste. All of the control variables are positive and significant, showing the decision-making of the waste management policy is highly related to the nearby municipalities whcih is in line with previous studies. We can interpret from the result that after the Great Heisei Consolidation, the merged municipalities tend not to charge for the disposal of combustible waste by about 3.6%. For the charging of incombustible waste, the value is about 4.5%.

Except for the charging of waste, another important thing for the residents when they dispose of waste is the waste separation rules. Municipalities are able to make their own waste separation rules, and generally, more detailed waste separation is supposed to improve recycling. The estimation results in column (3) of Table 2 shows a statistically insignificant result for the regression of the number of separation categories. Obtained results suggest that the municipal merges do not have a statistically significant effect on the separation rules of the merged municipalities.

The result of the event study analysis of the charging of combustible waste is plotted in Figure 2 with the responding 95% confidence interval provided. The confidence intervals of the pre-merger period contain zero which could be a piece of evidence for the parallel trend assumption. There is a substantial decrease after the merger and the effect has been negative and significant since then. However, the trend of the average ratio of the charging for combustible waste plotted in Figure 3, suggest that the treatment group has a higher rate for adopting charging policies for combustible waste all the time.[4]

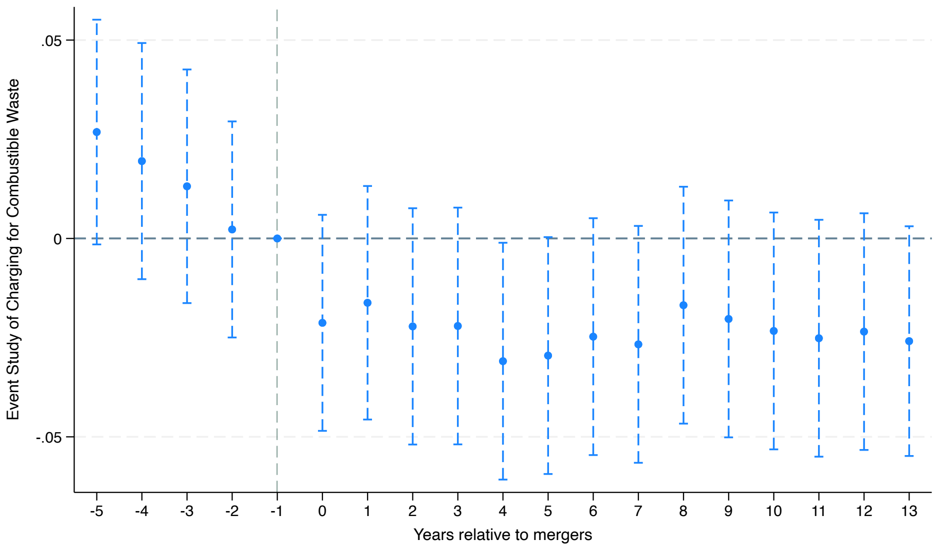

Figure 2: Event Study of Charging for Combustible Waste

[4]Appendix Figure A.1 shows the event study of the charging of incombustible waste and Appendix Figure A.2 shows the event study of the separation numbers for reference.

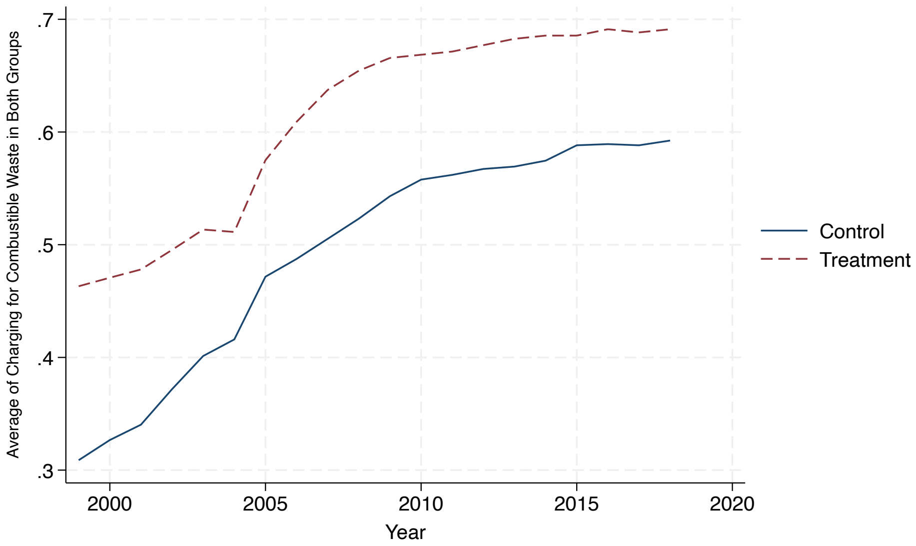

Figure 3: Average of Charging for Combustible Waste in Both Groups

Data regarding the policy implementation before mergers can take fractional values and cause difficulties when estimating them using the conventional Probit model. To address this, we follow Papke and Wooldridge (1996) and employ a fractional Probit regression by the generalized linear model using the Probit link function as the alternative method. The sample size of these methods is different from the baseline results as we exclude those municipalities that never changed their waste management policies during the research period. We do not apply MDM to this analysis because of the considerable decrease in the sample size. The results are shown in Table 3.

The results of the robustness check using GLM methods show a similar trend in the treatment effect. The Great Heisei Consolidation has a negative impact on the adoption of unit pricing policies for the combustible and incombustible waste. Although the size of the estimated coefficients is larger, these results support our baseline analysis in general.

Table 3: Robustness Check of The Effect of Municipal Mergers on Charging Policies

	(1) UP Combustible		(2) UP Incombustible	
	Probit	Marginal	Probit	Marginal
DiD	-0.637***	-0.102***	-0.867***	-0.151***
	(0.213)	(0.033)	(0.205)	(0.035)
Control Variables	YES	YES	YES	YES
Municipal FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	11,500	11,500	10,680	10,680

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In summary, the obtained results indicate that the municipal mergers did not promote more strict policies for waste management. We investigate the outcome effect further by looking at the municipal solid waste generation in the next subsection.

4.2 The Amount of Municipal Solid Waste Generation

Table 4 reports the estimated impact of the Great Heisei Consolidation on waste generation. Estimated coefficients are positive and statistically significant in the model (1) and (2) which use total waste and household waste as dependent variables, respectively. The estimations of both the coefficients of total municipal solid waste and the waste from households only are significant and positive. This result indicates that municipal mergers in Japan have a negative impact on the reduction of municipal waste generation. The residents in merged municipalities generate about 8.6 kg of per capita annually more waste after municipal mergers, which responds to 2.5% of the total waste. This result is consistent with Tsuzuki et al. (2018) who also captured an increase in the waste generation of the merged municipalities.

In addition, as previous studies show charging for waste will decrease the generation of waste (Usui and Takeuchi, 2013; Sasao, 2000), obtained results are consistent with our previous findings that the merged municipalities tend not to charge for the disposal of waste.

Table 4: The Effect on Waste Per Capita Considering Announcement Effect

	(1)	(2)
	Total Municipal Solid Waste	Waste from Households Only
DiD	0.0086***	0.0076***
	(0.0032)	(0.0026)
Municipal FE	YES	YES
Year FE	YES	YES
Treatment Group	353	353
Control Group	952	952
Observations	26,100	26,100

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The result of the event study is plotted in Figure 4 for the total municipal solid waste generation and the event study for the household solid waste generation only is plotted in Appendix Figure A.3 with the responding 95% confidence interval provided as well. We can observe a similar trend before the mergers and all the confidence intervals of the coefficients include zero in the pre-merger period. The plot of the average waste generation per capita in Figure 5 indicates that the treatment group always has a lower waste generation per capita than the control group even after the municipal mergers.

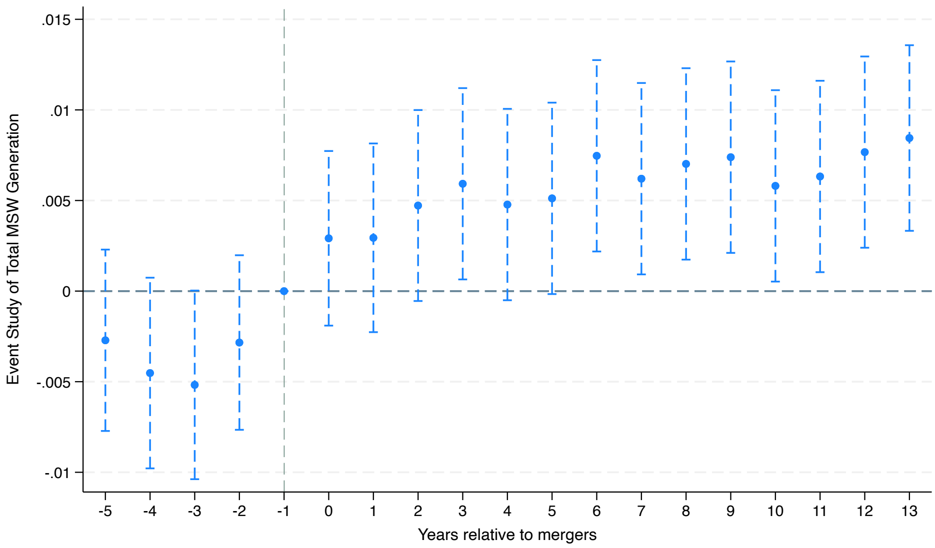

Figure 4: Event Study of The Total Waste Generation

Figure 5: The Anual Average of Waste Generation Per Capita in Both Groups

4.3 Plastic Waste

As plastic pollution has been a severe global problem (Ritchie and Roser, 2018), it is important to investigate if there is an effect of municipal mergers on plastic waste. PET bottles and plastic containers (including white trays, plastic containers, and other plastic wastes) are two representative categories of plastic waste collected in Japan. We attempt to measure the recycling of plastic waste by focusing on the amount of recycled PET bottles per capita and the amount of recycled plastic containers per capita.

Table 5: The Effect of Municipal Mergers on Plastic Waste

	(1)	(2)
	Amount of PET Bottles	Amount of Plastic Containers
DiD	-0.00014***	-0.00038
	(0.00005)	(0.00025)
Control Variables	NO	NO
Municipal FE	YES	YES
Year FE	YES	YES
Treatment Group	353	353
Control Group	952	952
Observations	26,100	26,100

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

We report the results of the amount of recycled PET per capita and the collection status of plastic container waste in Table 5. The estimated coefficient is statistically significant and negative for the amount of recycled PET bottles per capita while the coefficient of the amount of recycled plastic containers is not statistically significant. These results indicate that the amount of recycled PET bottles decreased after the municipal mergers, while we do not find any statistically significant effect of municipal mergers on the amount of recycled plastic containers.

The event study is also plotted in Figure 6 and Figure 7 with the responding 95% confidence interval provided. While not all the confidence intervals of coefficients in the pre-treated period include zero, we still reckon there is a similar trend for the amount of recycled PET bottles before the municipal mergers. However, we do not observe the parallel trend in the pre-treatment period regarding the amount of recycled plastic containers.

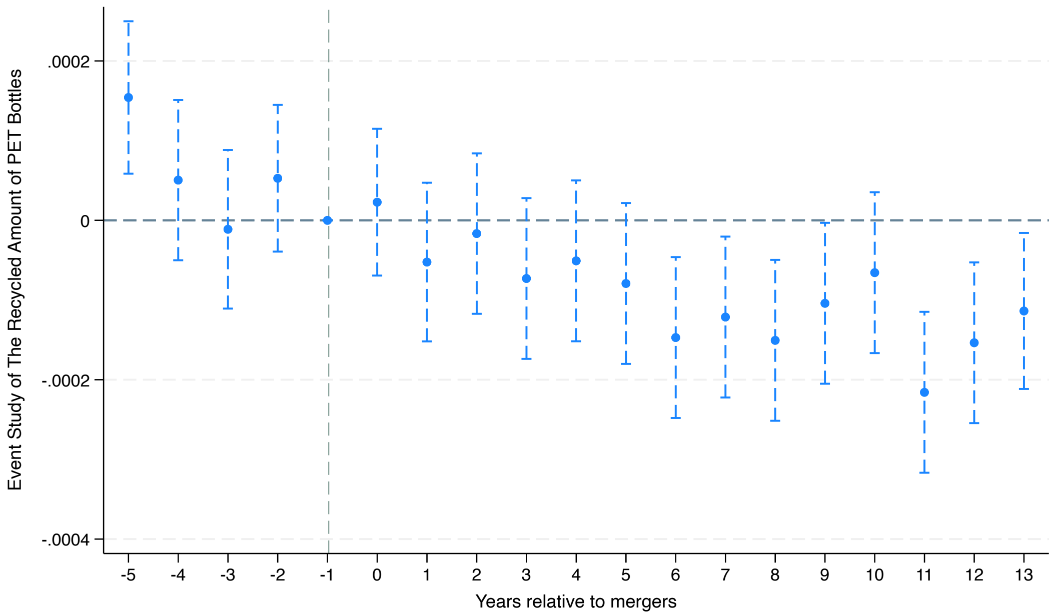

Figure 6: Event Study of The Amount of Recycled PET Bottles

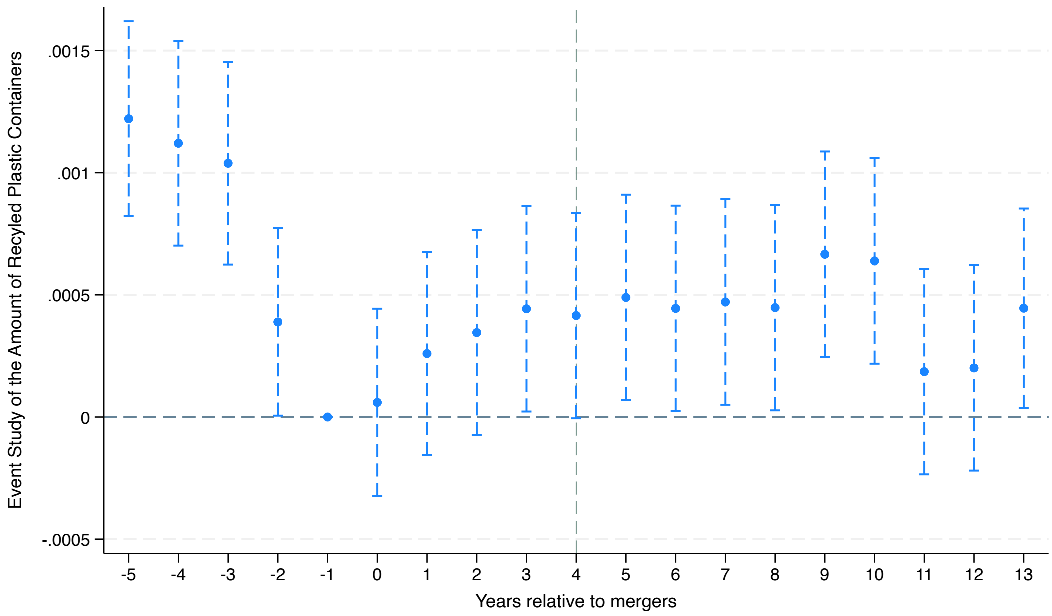

Figure 7: Event Study of The Amount of Recycled Plastic Container Waste

4.4 Discussion

The analyses above give a consistent and robust result that the Great Heisei Consolidation little contributes to the recycling of waste. It is consistent with the finding that a lower rate for charging combustible waste and incombustible waste in the merged municipalities. As we found that the amount of recycled PET bottles has decreased in the merged municipalities, it is possible that there are residents who dispose of plastic waste together with combustible waste if the municipalities do not charge for the disposal of combustible waste.

As the reasons for the higher rates of not charging for waste in the merged municipalities, it is likely that the coordination during the consolidation conferences before the implementation of municipal mergers affect the policy. If a municipality with policies of charging for the disposal of waste merged with others that do not charge for it, the politically easiest way might be to avoid the charging policy, as no one is willing to pay for something if they do not need to.

Another possible reason for this phenomenon may be the newer and larger incinerators. Merged municipalities could issue special bonds to build new projects including new incinerators. However, a new incinerator might have a larger capacity and is very likely to have underutilized furnaces, while higher excess capacity might require recyclables as fuel to increase the efficiency of the incinerators (Yamamoto and Kinnaman, 2022). Therefore, there is no need for the merged municipalities to implement a unit-based pricing to reduce the generation of waste.

5 Conclusion

Through the case study of the Great Heisei Consolidation in Japan, we examined whether municipal mergers could promote the recycling and reduction of municipal solid waste. Our analyses, however, indicate that the Great Heisei Consolidation might not promote recycling in general.

First, we find the Great Heisei Consolidation has a negative impact on the adoption of policies that charge for the disposal of municipal solid waste. Specifically, our results show that there are 3.6% and 4.5% fewer merged municipalities that choose to charge for the disposal of combustible and incombustible waste after the municipal mergers. We believe that the reason for this phenomenon lies in the coordination during the municipal mergers and the newly built facilities like incinerators. As for other waste management policies, we found that municipal mergers have no effect on the waste separation sorts.

Second, our baseline DID estimation shows the Great Heisei Consolidation has a negative impact on the reduction of waste generation as well. We find an 8.6 kg or 2.5% higher annual total waste per capita in the merged municipalities. The first and the second results are consistent and provide a new insight to the literature on the economics of waste management.

Furthermore, the amount of recycled PET bottles in the merged municipalities has decreased after the merger. As the Great Heisei Consolidation has a negative impact on the adoption of policies that charge for the disposal of municipal solid waste, there could be residents who do not separate the waste and throw the PET bottles along with the combustible waste.

Based on the findings, we conclude that municipal mergers do not always lead to strict waste management policies but looser ones instead. Policymakers should be careful of this when planning municipal mergers if a more sustainable and environmentally friendly society is their target.

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Appendix A Tables and Figures

Table A.1: Descriptive Statistics of the Variables Used for Matching

VARIABLES	N	Mean	Std. Dev.	Min	Max
Area	1,305	19246	22,773	347	142,756
Population	1,305	57,751	167,768	508	3.264×10^6
Percentage of Over 65 Years Olds	1,305	0.172	0.054	0.050	0.374
Net Balance of Settled Accounts	1,305	379,580	501,726	-1.687×10^6	4.952×10^6
Taxable Income per Capita	1,305	1,153	368	387	8,016
Agriculture Sales	1,305	5,569	6,808	0	66,995
Manufacturing Sales	1,305	146,290	392,712	0	6.271×10^6

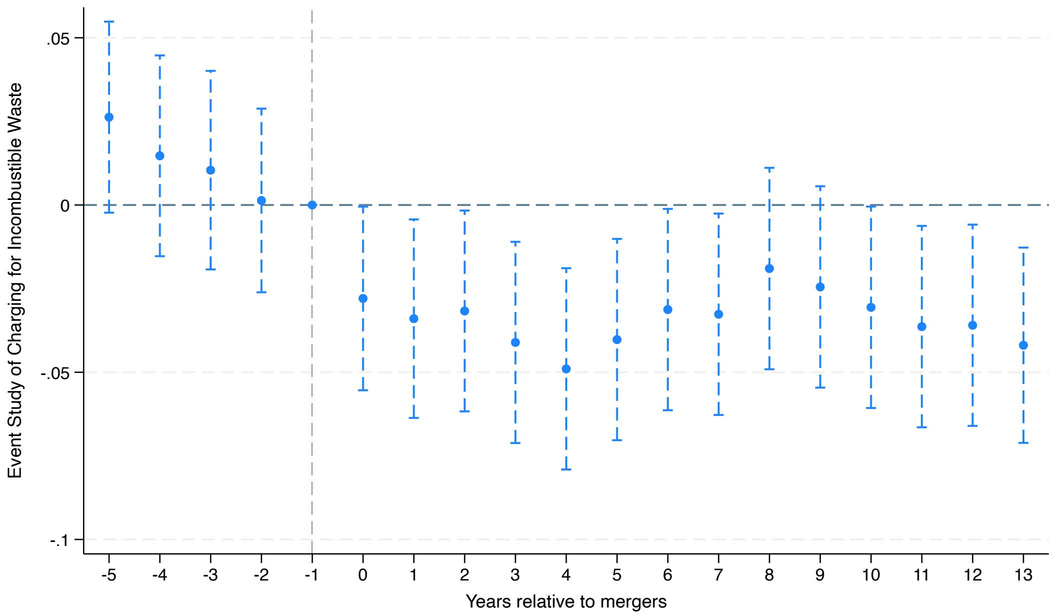

Figure A.1: Event Study of Charging for Incombustible Waste

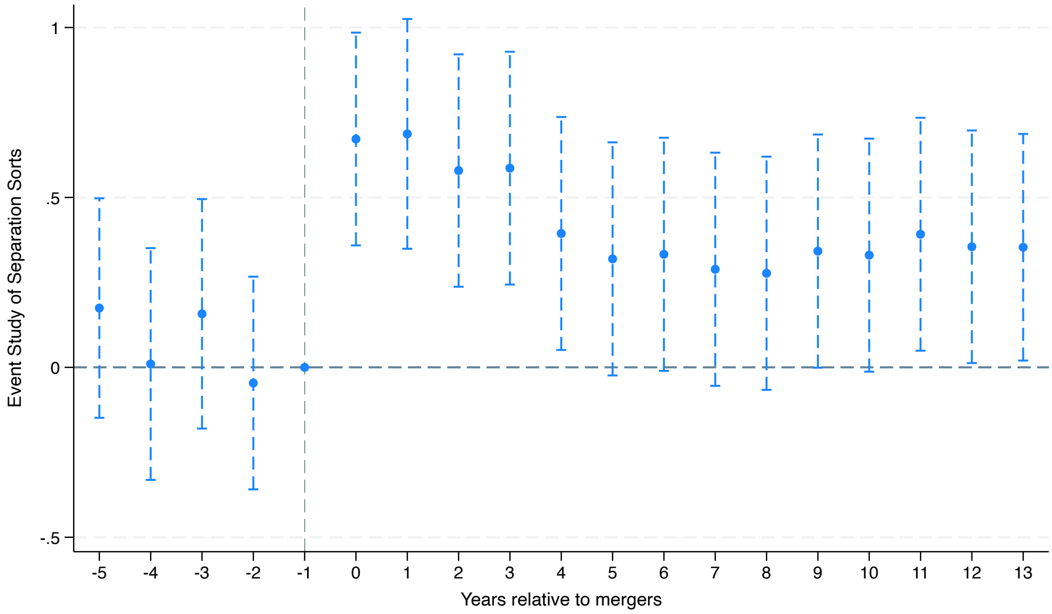

Figure A.2: Event Study of Separation Sorts

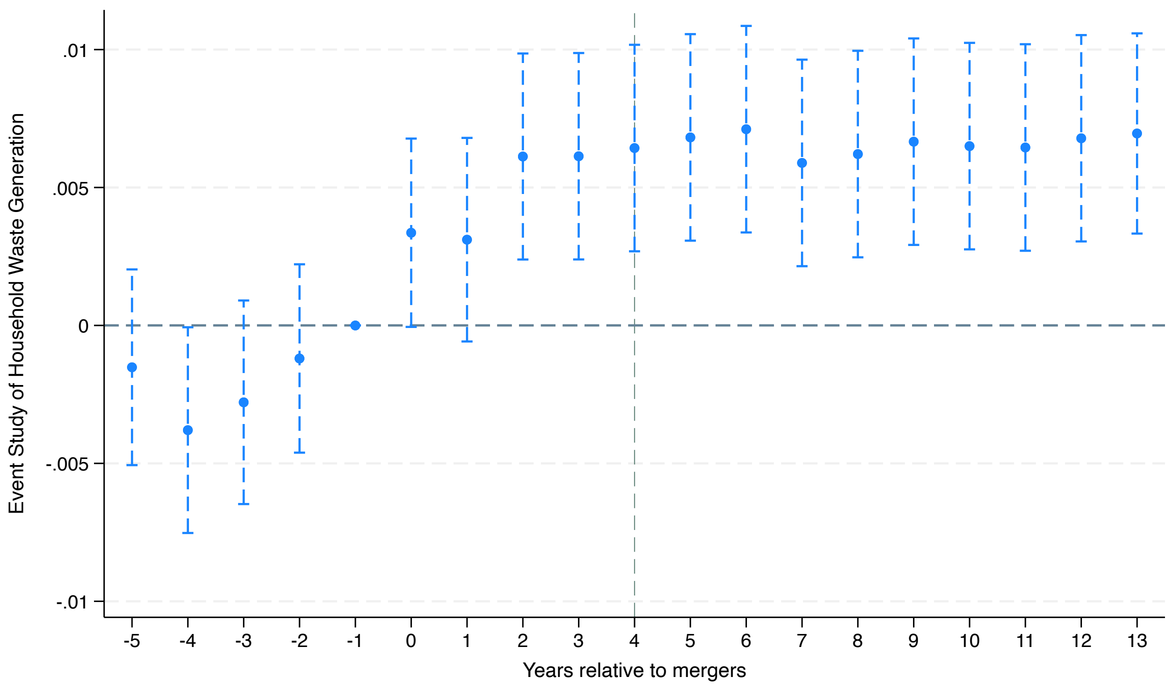

Figure A.3: Event Study of Household Waste Generation