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Cost saving with inter-municipal cooperation in waste disposal

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Abstract

This study investigates the effects of inter-municipal cooperation in municipal solid waste disposal on waste disposal costs. Using a dataset of disposal costs from 2006 to 2015 for all municipalities in Japan, we investigate whether inter-municipal cooperation in the disposal process induces economies of scale and scope. We find that municipalities with inter-municipal cooperation have lower disposal costs, and the effect is remarkable in municipalities with smaller waste emission scale. Our results also show that cooperation in multiple disposal processes is more effective for cost reduction, which suggests the presence of scope economies. These results indicate that economies of scale and scope play a significant role in the cost efficiency of municipal solid waste disposal.

JEL classification: Q53, Q58, H73

1. Introduction

The shortage of waste for disposal has recently become an important issue for waste management and government finance in many countries. Governments in developed countries face cost inefficiency induced by a shortage of waste disposed in facilities, while many schemes such as promoting recycling, waste reduction, and energy generation from waste are successful. For instance, Sweden has imported about 800,000 tons of waste annually from other countries owing to its efficiency in converting waste to renewable energy (NPR, 2012). In Japan too, the slack capacity of municipal solid waste (MSW) incinerators has been increasing, and was about 55% in 2015. Japanese government spending on MSW management increased 5% from 2006 to 2015, even though the amount of waste decreased 15% during the same period. From the viewpoint of cost efficiency, it is important to maintain the optimal amount of waste that induces the economies of scale in waste management.

The purpose of this study is to investigate the effect of inter-municipal cooperation in MSW disposal on cost reduction in the public service. By using a dataset of 17,067 items of disposal costs in Japanese municipalities from 2006 to 2016, we estimate the impact on disposal costs of economies of scale and scope resulting from the cooperation. While many studies focus on cooperation only at the collection stage (Bel and Costas, 2006; Dijkgraaf and Gradus, 2007, 2015; Sorensen, 2007), we focus on the overall cost structure and inter-municipal cooperation at the treatment stages, including incineration, recycling, and final disposal. Waste treatment costs constitute a larger proportion of the total cost for waste management than do waste collection costs. Specifically, treatment costs account for 60% of total costs in MSW management in Japan. Thus, in such a climate of financial pressure and decreasing waste disposal volume, it is important to consider the impact of inter-municipal cooperation in the treatment process on the efficiency of waste disposal. In addition, while cost data for the waste treatment stage are rarely available, the detailed and standardized data reported annually by the Japanese central government enable us to analyze the effect of cooperation at the treatment stage.

Few empirical studies have investigated the effect of inter-municipal cooperation at the treatment stage. Bel and Mur (2009) find that implementing inter-municipal cooperation is effective for cost reduction in municipalities with small populations. Based on a Japanese dataset, Chifari et al. (2017) investigated the economies of scale induced by cooperation in any one of the processes including collection, intermediate disposal, and final disposal. The authors find that municipalities with cooperation tend to have 23% lower total costs than do municipalities without cooperation, and they argue that the size of Japanese municipalities has less of an impact than does the cost-minimizing level.

There are two important differences between the abovementioned studies and ours. First, we separate the cooperation stage into different treatment processes, including incineration, recycling, final disposal, and others, as the effect of scale economies may be different for each process. While increasing waste disposal in a facility through cooperation can raise an incineration facility's operation to a more efficient level, it reduces the residual capacity of landfill sites and increases the need to expand the capacity of sites. Thus, we focus on the effect of cooperation in *each* process on cost reduction, while Bel and Mur (2009) and Chifari et al. (2017) do not make such a differentiation. Second, we focus not only on economies of scale, but also on economies of scope induced by inter-municipal cooperation. In Japan, some municipalities cooperate with neighboring municipalities in multiple disposal processes (i.e., both incineration and recycling processes). Thus, such a situation may lead to economies of scope and further cost reduction, in addition to economies of scale. Callan and Thomas (2001) show that municipalities implementing both waste disposal and recycling have lower total treatment costs than do municipalities implementing only one of these processes. Our estimation results show that inter-municipal cooperation in multiple disposal processes is more effective for cost reduction than cooperation in only one disposal process.

The remainder of this paper is organized as follows. Section 2 describes the background on inter-municipal cooperation in Japan. Section 3 introduces the data, empirical strategy, and model specification. Section 4 provides the estimation results for the cost saving of inter-municipal cooperation. Section 5 concludes and discusses policy implications.

2. Background

In Japan, the number of MSW disposal facilities and the operation rate has been decreasing owing to the decrease in waste disposal volume. The operation rate of incineration facilities in 2015 was about 55% on average. In addition, the number of waste disposal facilities decreased by 9% for incineration facilities and 12% for landfill sites from 2006 to 2015. Considering Japan's projected future population decline, the waste disposal volume is expected to decrease further. Therefore, inter-municipal cooperation that brings economies of scale could play an important role in cost efficiency for MSW management.

In 1997, the Japanese Ministry of Environment introduced guidelines for regional waste management programs, referred to as the Area Wide Program of Waste Disposal, to promote inter-cooperation of waste disposal in municipalities. In Japan, each municipality typically implement MSW management in its own jurisdiction. Although such an arrangement seems to be effective from the perspective of fairness in terms of the location of waste disposal facilities, which are recognized as unwanted facilities by local communities (Sasao, 2004; Ishimura and Takeuchi, 2017), it might not bring economies of scale and comparative advantages. Regarding the decreasing amount of waste disposed at incineration facilities and landfill sites owing to such schemes as the promotion of recycling and waste reduction, the construction of large-scale waste disposal facilities in all municipalities leads to cost inefficiency in MSW management.

Table 1 shows the number of municipalities that implemented inter-municipal cooperation in 2006 and 2015. A total of 1,247 (73%) municipalities implemented inter-municipal cooperation in any one of treatment processes in 2015, and this proportion hardly changed during the preceding 10 years.[1] In detail, the largest proportion of municipalities implemented cooperation in the incineration process (63%). Meanwhile, more than half of municipalities implemented cooperation in multiple treatment processes. When a municipality implements inter-municipal cooperation with neighboring municipalities, these municipalities organize the administrative association for waste management. The average number of municipalities constituting an association is four municipalities for the incineration process, five for recycling, and five for final disposal in landfill sites. Some waste management associations dispose of their waste through multiple disposal processes, while others use a single process.

Table 1: Number of municipalities implementing inter-municipal cooperation

	2006		2015	
		%		%
Cooperation in each treatment process	1,211	70	1,247	73
Without cooperation	507	30	471	27
Cooperation in incineration	1,039	60	1,084	63
Cooperation in recycling	689	40	735	43
Cooperation in final disposal	766	45	799	47
Only incineration	176	10	177	10
Only recycling	37	2	21	1
Only final disposal	38	2	46	3
Other processes	58	3	44	3
Incineration and recycling	174	10	206	12
Incineration and final disposal	250	15	245	14
Recycling and final disposal	39	2	52	3
All treatment processes	439	26	456	27
Total	1,718	100	1,718	100

Note: Due to a lack of data, we exclude municipalities belonging to Tokyo special wards. The 2006 data represent the number of municipalities after municipal mergers. Cooperation in other processes includes storage facilities, fueling facilities, and composting facilities, among others.

3. Model and Data

In this study, we investigate the impact of scale and scope economics induced by inter-municipal cooperation on the disposal costs of MSW. We use a dataset of items of

[1] Local Japanese governments comprise two tiers: prefectural governments and municipalities (cities, towns, and villages). The nation has 47 prefectures. There were 1,718 municipalities as of April 2016.

disposal costs from 2006 to 2015 for 1,718 municipalities, totaling 17,067 observations.[2] The basic cost function for MSW disposal is represented as follows (Bel and Costas, 2006):

$$TC = f(W, P, X, Z), \tag{1}$$

where *TC* is the total cost of the waste management service in a municipality. The total cost is determined by output of waste *W*, input price *P*, some other characteristics *X* of the output, and non-controllable characteristics *Z* that affect disposal costs. From cost function (1), the model for MSW disposal costs in municipal governments is specified as follows:

$$ln\frac{TC_i}{W_i} = \beta_0 + \beta_1 Coop + \beta_2 Coop\_multi + \beta_3 Coop\_single + \beta_4 Prive + \beta_5 lnDens_i$$
$$+\beta_6 WQ2 + \beta_7 WQ3 + \beta_8 WQ4 + YD + u_i, \tag{2}$$

where TC_i is the total cost in municipality *i* and W_i is the total amount of waste in the disposal process, including collection, intermediate disposal, and final disposal in landfill sites. Thus, we use the total costs divided by total quantity as the dependent variable.

Importantly, for the explanatory variable, we include whether municipalities have introduced inter-municipal cooperation. *Coop* is a dummy variable that takes 1 for a municipality in which waste is disposed by inter-municipal cooperation with neighboring municipalities in the treatment processes. We expect the effect of this variable to be significantly negative for municipalities with cooperation. The implementation of inter-municipal cooperation may reduce disposal costs owing to economies of scale. In addition, use of disposal facilities with multiple municipalities

[2] Owing to a lack of data, there are 113 missing observations (i.e., data of municipalities belonging to Fukushima prefecture where the Fukushima Daiichi nuclear power plant accident occurred in 2011).

reduces costs related to the management and operation of facilities, and fixed costs related to construction and equipment.[3]

Coop_multi is a dummy variable that takes 1 for municipalities that implement inter-municipal cooperation in multiple disposal processes (i.e., both incineration and recycling processes). *Coop_single* is a dummy variable that takes 1 for municipalities that implement inter-municipal cooperation in only one disposal process (i.e., only incineration process). We use these two variables to investigate the existence of economies of scope in inter-municipal cooperation. Inter-municipal cooperation in multiple disposal process may bring economies of scope. For instance, when the same association operates more than one disposal facility, and since each disposal facility is often located in the same area, it is possible to reduce transportation costs between facilities. In addition, common costs, such as labor costs and operational costs of facilities, may be lower than cooperation in only one disposal process.

Priv is a privatization dummy variable. Several studies suggest that privatization in the collection process lowers costs (Stevens, 1978; Dijkgraaf and Gradus, 2003; Chifari et al., 2017; Soukopova et al., 2017).[4] Thus, we use a dummy variable that takes 1 for municipalities that use a private collection firm. $Dens_i$ denotes the population density in municipality i. A municipality with higher population density charges lower transportation costs to collect waste per disposal trip. *WQ* is a dummy variable related to the waste output level, and is also a simple measure of scale economies. The waste output level is classified using quartile groups: a second quartile group *WQ2* (5,226 tons $\leqq$ waste < 16,333 tons), a third quartile group *WQ3* (16,333 tons $\leqq$ waste < 42,353 tons), and a fourth quartile group *WQ4* (42,353 tons $\leqq$ waste). As our control variable, we use a year dummy variable, *YD*.

The usual model for panel data analysis is ordinary least squares (OLS) with fixed-effects and random-effects. However, as the value of each variable used in this analysis

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3 As the data related to such fixed costs are not available, we focus on running costs, such as operation and maintenance costs of treatment facilities.

4 In contrast to these studies, Ohlsson (2003) shows that the public production cost of the collection process is lower than the private production cost in Sweden.

hardly changes throughout the study period, panel data analysis would remove the impact of each variable on disposal costs by simultaneously removing the fixed effects. Therefore, in this study, we use the pooled OLS method, which is similar to such previous studies as by Zafra-Gómez et al. (2013) and Dijkgraaf and Gradus (2015).

Table 2 presents the summary statistics of the data we use for the pooled data model. The data on the implementation status of inter-municipal cooperation, privatization of waste collection, disposal costs, and the amount of waste output are extracted from a survey report on MSW by the Japanese Ministry of Environment. The population density and population data are obtained from the 2005, 2010, and 2015 National Census of the Japanese Ministry of Internal Affairs and Communications for the respective years.

Table 2: Descriptive statistics

Variable	Description of data	Unit	Mean	Std. Dev.	Min	Max
Total cost	Total cost for waste disposal in all treatment processes	thousands of yen	928,811.000	2,617,120.000	1,596.000	56,700,000.000
Waste volume	Total amount of waste disposed in all treatment processes	tons	23,755.550	64,581.790	24.000	1,599,495.000
Average cost	Total costs divided by total quantity	thousands of yen/t	23.487	19.799	1.325	866.329
Coop	1=municipality with inter-municipal cooperation, 0=otherwise	dummy	0.712	0.453	0.000	1.000
Coop_multi	1=municipality with inter-municipal cooperation in multiple treatment processes, 0=otherwise	dummy	0.528	0.499	0.000	1.000
Coope_single	1=municipality with inter-municipal cooperation in single treatment process, 0=otherwise	dummy	0.141	0.348	0.000	1.000
Priv	1=municipality with privatization in collection process, 0=otherwise	dummy	0.800	0.400	0.000	1.000
Dens	Density of population	people/km^2	867.123	1760.850	0.200	14140.900

4. Results

4.1 Cost Efficiency of Inter-municipal Cooperation

Tables 3 and 4 present the estimated results. The first columns of the tables present the results for aggregate samples. These tables also present the results for different waste emission scale subgroups: first quartile group (column 2), second quartile group (column 3), third quartile group (column 4), and fourth quartile group (column 5).

Table 3 shows the estimation results of scale economies in inter-municipal cooperation. The coefficient of *Coop* is negative and statistically significant at least at the 1% level in all models. In municipalities with inter-municipal cooperation in the treatment processes, disposal costs are lower than that of municipalities without cooperation. This result suggests that inter-municipal cooperation leads to economies of scale in waste disposal, which supports the findings of Chifari et al. (2017). The coefficient in the first column of Table 3 implies that the disposal costs of municipalities with inter-municipal cooperation are approximately 22% lower per ton than those of municipalities without cooperation. Furthermore, according to the results from columns 2 to 5, the value of the coefficient decreases as the waste emission scale decreases. These results show that municipalities with lower waste emissions tend to have more economies of scale by implementing inter-municipal cooperation, which supports Bel and Mur's (2009) finding that the implementation of cooperation is effective for cost reduction in municipalities with small populations.

The coefficients of *WQ2*, *WQ3*, and *WQ4* are statistically significant and negative in the results for aggregate samples (column 1). The coefficient of *WQ4* is smaller than that of *WQ3* and *WQ2*. These results show that the larger the waste emission scale, the lower are the total disposal costs per ton, suggesting that municipalities with small waste emission scale can reduce disposal costs by implementing cooperation to expand disposal scale. Population density is statistically significant with negative coefficients. Municipalities with higher population density are likely to have lower transportation costs because the distance between households is shorter.

The coefficient on *Priv* is statistically significant and positive. This result shows that the disposal costs in municipalities with privatization are higher than those in municipalities with public production, which is in contrast to the findings of Stevens (1978), Dijkgraaf and Gradus (2003), Chifari et al. (2017), and Soukopova et al. (2017). Thus, our estimation results indicate that Japanese municipality-level data do not support the cost efficiency of contracting out waste collection. One reason for this result may be the type of contract. When municipalities implement contracting out by discretionary contracts, the collection market in these areas becomes the monopoly market, since the same private firm contracts with the municipality for a long time. In addition, even if perfect competitive bidding exists, municipalities need to retain their own refuse collection vehicles and labor in order to deal with the temporary collection of disaster waste.[5]

Table 4 shows the estimation results of the scope economies in inter-municipal cooperation. The coefficients of $Coop\_{multi}$ and $Coop\_{single}$ are negative and statistically significant, at least at the 1% level in column 1. Comparing the values of the coefficients, $Coop\_{multi}$ has a lower value than $Coop\_{single}$. These results show that the treatment costs tend to be lower in municipalities with cooperation in multiple treatment processes than in municipalities with cooperation in only one treatment process. This finding suggests that cooperation in multiple treatment processes brings not only scale economies, but also scope economies.

[5] Data restrictions make it difficult to examine the impact of differences in contract type on waste collection cost.

Table 3: Estimation results of scale economies

	All	Quartile 1	Quartile 2	Quartile 3	Quartile 4
	(1)	(2)	(3)	(4)	(5)
Coop	-0.222 ***	-0.332 ***	-0.284 ***	-0.260 ***	-0.073 ***
	(0.008)	(0.021)	(0.019)	(0.014)	(0.011)
Priv	0.210 ***	0.159 ***	0.229 ***	0.258 ***	0.142 ***
	(0.010)	(0.018)	(0.018)	(0.019)	(0.032)
lnDens	-0.018 ***	-0.102 ***	-0.043 ***	0.002	0.069 ***
	(0.003)	(0.006)	(0.005)	(0.005)	(0.005)
WasteQ2	-0.363 ***				
	(0.012)				
WasteQ3	-0.429 ***				
	(0.013)				
WasteQ4	-0.495 ***				
	(0.015)				
Constant	3.283 ***	3.712 ***	3.068 ***	2.737 ***	2.169 ***
	(0.020)	(0.042)	(0.038)	(0.042)	(0.050)
Year dummy	YES	YES	YES	YES	YES
R^2	0.215	0.155	0.142	0.160	0.114
Obs.	17,067	4,267	4,267	4,266	4,267

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

Table 4: Estimation results of scope economies

	All	Quartile 1	Quartile 2	Quartile 3	Quartile 4
	(1)	(2)	(3)	(4)	(5)
$Coop_{\_multi}$	-0.257 ***	-0.356 ***	-0.350 ***	-0.270 ***	-0.089 ***
	(0.008)	(0.020)	(0.017)	(0.014)	(0.012)
$Coop_{\_single}$	-0.074 ***	-0.074 ***	-0.072 ***	-0.175 ***	-0.020
	(0.011)	(0.028)	(0.023)	(0.018)	(0.018)
Priv	0.193 ***	0.132 ***	0.207 ***	0.246 ***	0.139 ***
	(0.010)	(0.018)	(0.017)	(0.020)	(0.032)
lnDens	-0.017 ***	-0.103 ***	-0.043 ***	0.001	0.070 ***
	(0.003)	(0.006)	(0.005)	(0.005)	(0.005)
WasteQ2	-0.356				
	(0.012)				
WasteQ3	-0.428				
	(0.013)				
WasteQ4	-0.485				
	(0.015)				
Constant	3.279 ***	3.687 ***	3.091 ***	2.731 ***	2.161 ***
	(0.019)	(0.040)	(0.037)	(0.043)	(0.049)
Year dummy	YES	YES	YES	YES	YES
R^2	0.230	0.176	0.190	0.163	0.117
Obs.	17,067	4,267	4,267	4,266	4,267

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

4.2 Effects of Inter-municipal Cooperation in Each Process

In this subsection, we divide the influence on disposal costs of implementing inter-municipal cooperation in each treatment process, namely, incineration, recycling, and final disposal. In addition, we investigate which combination of cooperation is more effective for cost reduction.

We estimate the following cost price:

$$ln\frac{TC_i}{W_i} = \beta_0 + \beta_1 Coop_{INC} + \beta_2 Coop_{REC} + \beta_3 Coop_{LAND} + \beta_4 Coop_{OTHER} + \beta_5 Coop_{INC\_REC} + \beta_6 Coop_{INC\_LAND} + \beta_7 Coop_{REC\_LAND} + \beta_8 Coop_{ALL} + \beta_9 Priv + \beta_{10} lnDens_i + YD + \varepsilon_i, \quad (3)$$

where $Coop_{ING}$, $Coop_{REC}$, $Coop_{LAND}$, and $Coop_{OTHER}$ are dummy variables that take 1 for a municipality in which waste is disposed by inter-municipal cooperation with neighboring municipalities in only incineration, recycling, final disposal, and another treatment process, respectively. $Coop_{INC\_REC}$, $Coop_{INC\_LAND}$, and $Coop_{REC\_LAND}$ are dummy variables related to the combination of the respective cooperation in the treatment processes, and $Coop_{ALL}$ is a dummy variable related to the implementation of cooperation in all disposal processes. The other variables are the same as those in the previous section.

Table 5 shows the estimation results of the effect of cooperation in each process. The coefficient of $Coop_{INC}$ is negative and statistically significant in all models. Even if cooperation exists only for incineration process, municipalities that dispose waste with neighboring municipalities tend to have lower disposal costs than municipalities that dispose waste alone. $Coop_{INC\_REC}$ is negative and statistically significant in all models, while $Coop_{REC}$ is not significantly related to lower disposal costs. Similarly, $Coop_{INC\_LAND}$ is negative and statistically significant in all models, while $Coop_{LAND}$ is not significantly related to lower disposal costs. These results suggest that cooperation in multiple disposal processes leads to economies of scope and lower disposal costs. $Coop_{ALL}$ is also negative and statistically significant in all models. The values of the coefficients of $Coop_{ALL}$ are lower than those of $Coop_{INC}$, $Coop_{REC}$, and $Coop_{LAND}$ at each emission scale. These results show that municipalities implementing cooperation in all treatment processes tend to have lower disposal costs than municipalities implementing cooperation in only one of the treatment processes. Thus, these results suggest that cooperation in multiple treatment processes leads to economies of scope and further cost reduction, which support the results reported in the previous subsection.

Table 5: Estimation results of the effect of cooperation in each process

	All (1)	Quartile 1 (2)	Quartile 2 (3)	Quartile 3 (4)	Quartile 4 (5)
$Coop_{INC}$	-0.114 ***	-0.168 ***	-0.131 ***	-0.248 ***	-0.035 *
	(0.013)	(0.032)	(0.027)	(0.020)	(0.019)
$Coop_{REC}$	0.007	-0.332 ***	-0.024	0.066 *	0.055
	(0.023)	(0.053)	(0.040)	(0.036)	(0.041)
$Coop_{LAND}$	0.122 ***	0.098 *	0.096 *	-0.096 ***	-0.032
	(0.032)	(0.059)	(0.057)	(0.036)	(0.052)
$Coop_{OTHER}$	-0.080 ***	-0.272 ***	-0.023	-0.152 ***	-0.022
	(0.018)	(0.039)	(0.035)	(0.033)	(0.024)
$Coop_{INC\_REC}$	-0.112 ***	-0.157 ***	-0.150 ***	-0.231 ***	-0.113 ***
	(0.012)	(0.030)	(0.023)	(0.021)	(0.017)
$Coop_{INC\_LAND}$	-0.363 ***	-0.543 ***	-0.461 ***	-0.343 ***	-0.194 ***
	(0.012)	(0.027)	(0.023)	(0.020)	(0.022)
$Coop_{REC\_LAND}$	0.004	-0.345 ***	-0.123 ***	-0.069 *	0.284 ***
	(0.022)	(0.039)	(0.038)	(0.037)	(0.032)
$Coop_{ALL}$	-0.278 ***	-0.446 ***	-0.427 ***	-0.291 ***	-0.077 ***
	(0.010)	(0.024)	(0.022)	(0.018)	(0.015)
Priv	0.131 ***	0.103 ***	0.187 ***	0.253 ***	0.128 ***
	(0.010)	(0.018)	(0.017)	(0.020)	(0.032)
lnDens	-0.085 ***	-0.105 ***	-0.045 ***	0.002	0.064 ***
	(0.002)	(0.006)	(0.005)	(0.005)	(0.004)
Constant	3.374 ***	3.771 ***	3.133 ***	2.742 ***	2.222 ***
	(0.020)	(0.041)	(0.038)	(0.042)	(0.049)
Year dummy	YES	YES	YES	YES	YES
R^2	0.183	0.221	0.239	0.185	0.149
Obs.	17,067	4,267	4,267	4,266	4,267

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

5. Conclusions

This study investigated the relationship between costs of MSW management and inter-municipal cooperation in waste disposal. Our results suggest that inter-municipal cooperation in incineration processing leads to economies of scale, especially in municipalities with smaller emission scale. If there is a larger slack capacity in disposal facilities, municipalities can raise the efficiency of the facility's operation by disposing waste with other municipalities. Previous studies have focused on inter-municipal cooperation in the waste collection process. The contribution of this study is that we show that cooperation is effective for cost reduction, even in treatment processes that include intermediate processing and final disposal. In addition, the results of this study show that a combination of cooperation in multiple disposal processes leads to economies of scope. We find that inter-municipal cooperation in multiple disposal processes is more effective for cost reduction than cooperation in only one of the treatment processes. Inter-municipal cooperation of public service may be essential for further reducing government spending.

Our results provide some implications for MSW management. Since inter-municipal cooperation is often implemented among local governments within the same administrative area such as prefecture and state, cooperation might not sufficiently bring economies of scale and scope. Therefore, from the viewpoint of cost efficiency, trade liberalization of waste disposal beyond the boundary of the administrative area may play a significant role in guaranteeing sufficient waste volumes and bring cost efficiency for MSW management.

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