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The effect of unit pricing on illegal dumping : Empirical evidence from the household electric appliance recycling program in Japan

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The effect of unit pricing on illegal dumping: Empirical evidence from the household electric appliance recycling program in Japan

Shigeru Matsumoto [1,2] Kenji Takeuchi [3]

ABSTRACT

Unit pricing programs reduce wastes disposal and promote recycling but may increase illegal dumping. The effect of the unit programs on illegal dumping has not been formally analyzed because the data on illegal dumping is scarcely available. We utilize the municipality-level data of the illegal dumping of waste household electric appliances in Japan and analyze the effect of the pricing program. We find that the increase in the legal disposal cost leads to the increase in illegal dumping. We also find that the surveillance and report system is important for the prevention of illegal dumping.

Key Words: Wastes, Recycling, Illegal Dumping, Enforcement

JEL Classification: K42, K32, R20, Q58

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I. Introduction

Until recently, waste management had been regarded as the responsibility of the government. The government disburses from its general account the necessary funds for the expenditure on waste management. In such a waste management program, costs for disposal and recycling will not be reflected appropriately to production and consumption activities. Firms will have no incentive to produce or develop products that generate less waste and are easily recyclable. Further, under this scheme, households will not understand the economic rationale behind reducing waste and recycling the appropriate volume of waste.

As site selection and construction of final disposal facilities becomes more expensive and difficult, waste reduction and the promotion of recycling are being addressed seriously in the public policy. A variety of unit pricing programs have been introduced for waste reduction and the promotion of adequate recycling activities. Under these programs, households are charged disposal or recycling fees when they dispose of or recycle used products. Unit pricing programs provide households with an incentive to choose products that are durable and easily recyclable.

Unfortunately, these programs may have a negative consequence: illegal dumping. The previous studies that examined the household responses to unit pricing programs demonstrated that households reduced waste disposal and strengthened recycling activities after the introduction of unit pricing programs, while they also suggest some reduction of waste is attained by increase in illegal dumping.[1]

Illegal dumping results in various kinds of problems, such as the deterioration of the local landscape. If the runoff from dumpsites contains toxic chemicals and contaminates water reservoirs, it can lead to significant health risks. The financial burden for a local government to clean up illegally dumped debris would also be substantial.

The attractiveness of unit pricing programs depends crucially on the extent of illegal dumping. If we identify the factors that cause illegal dumping, we can complement the deficiency of unit pricing programs and formulate an appropriate waste management policy. Therefore, it is important to investigate the determinants of illegal dumping and to find an effective enforcement activity. Nevertheless, the research on this topic is very limited. This is mainly because data on

illegal dumping is scarcely available. Using a unique dataset on dumping of home appliances in Japanese municipalities, this paper analyzes the causes of illegal disposal and evaluates the impacts of the enforcement activities to mitigate it.

The Japanese government introduced the Law for Recycling of Specified Kinds of Home Appliances generally called Japanese Home Appliance Recycling Law, on April 1, 2001. After the implementation of this law, the recycling fees are charged when households return used appliances to retailers, thereby the disposal fees for used electric appliances have increased drastically. Due to this characteristic of a pay-after-use system, a great deal of concern has been expressed regarding the increase in illegal dumping. In order to examine the situation of illegal dumping, local governments have investigated and recorded the incidents. Using these records, we examine the determinants of illegal dumping and evaluate the effectiveness of the enforcement activities.

The rest of the paper is organized as follows. In the following section, we explain the Japanese Home Appliance Recycling Law. In Section III, we summarize the situation of illegal dumping of used electric appliances. In Section IV, we estimate the determinants of illegal dumping. The result of our analysis reveals that the incidence increases as the legal disposal cost increases. We find that illegal dumping is more serious in municipalities with lower income and education and higher unemployment rates. In order to mitigate the problem, local governments have adopted various enforcement activities. In Section V, we evaluate the effectiveness of these enforcement activities. We find that the surveillance and report systems have contributed to the reduction of illegal dumping. Other enforcement activities are found to have minor or insignificant impacts. Section VI presents our conclusions.

II. Background

The Japanese Home Appliance Recycling Law came into effect on April 1, 2001. The law stipulates the responsibilities of consumers, retailers, and manufacturers under the new recycling program. Manufactures are responsible for recycling four appliances: televisions, refrigerators, washing machines, and air conditioners.[2] Manufacturers are grouped into Group A (Matsushita, Toshiba, and others) and Group B (Hitachi, Sanyo, Sharp, Sony, Fujitsu, Mitsubishi and others). The

manufacturers in the same group cooperatively built and operate collection depots and recycling plants. Consumers are responsible for returning used appliances to retailers, and retailers must deliver these used appliances to the collection depot. Used appliances are then sent to the recycle plants of manufacturers.

One of the unique features of the program is that consumers have to pay the recycling fees when they return used appliances to retailers. Thus, in Japan, a "payment-after-use system" is adopted for the collection of the recycling fees. This is in contrast to Europe where Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) prescribes that consumers are able to return their used appliances free of charge. [3]

Why did the Japanese government decide to adopt the payment-after-use system, which may encourage illegal dumping? There are two attractive features about it. First, households have been using a large number of electric appliances prior to the implementation of the recycling law. The payment-after-use system allows the collection of recycling fees for products that were sold before the enforcement of the law. Second, the usages periods of electric appliances are considerably long. During the usage periods, the collection cost and recycling process might change. The payment-after-use system can reflect the change in the economic conditions.

Most manufactures in Japan charge identical fees for the recycling of home appliances. The recycling fees are 3,500 yen (29.2 dollars) for air conditioners, 2,700 yen (22.5 dollars) for televisions, 4,600 yen (38.3 dollars) for refrigerators, and 2,400 yen (20.0 dollars) for washing machines. [4] Consumers have to pay these recycling fees to retailers when they replace old appliances with new ones. They also have to pay transportation fees to ask the retailers to deliver used appliances to recycling plants. The transportation fees differ from retailer to retailer and depend on the size of the appliance.

Prior to the enforcement of the new recycling law, municipalities collected the four electric appliances under the category of "bulky garbage." [5] Although some municipalities charged households a collection fee for the service of collecting bulky garbage, a majority of the charge were less than 1,500 yen (12.5 dollars). When households purchased new appliances, they occasionally asked retailers to dispose of the used ones, for which most retailers charged between 1,000 yen (8.3

dollars) and 2,000 yen (16.7 dollars). See Yamatani (2000).

In brief, the disposal fees of the four appliances have drastically increased since the enforcement of the new recycling law. Overall, the disposal fees are more than doubled from the previous levels. Therefore, it is not surprising that a great deal of concern has been expressed about the increase in illegal dumping. In a survey by Japanese Ministry of the Environment, 95.1% of the local governments have expressed their concern (Japanese Ministry of the Environment 2002). In October 2000, the central government increased the maximum penalty for the illegal dumping of municipal solid waste. At present, the maximum penalty for an individual who carries out illegal dumping is five years' imprisonment and/or a fine of ten million yen. The maximum penalty for a company is a fine of one hundred million yen.

In order to examine the situation of illegal dumping, municipalities investigate the incidents of illegal dumping and report the results to the Japanese Ministry of the Environment. In Section 4, we use this dataset to evaluate the community characteristics that influence illegal dumping. In order to tackle the illegal dumping problems, the municipalities introduced various enforcement activities after the enforcement of the new recycling law. In section 5, we evaluate their effectiveness by using data on the enforcement activities.

Research on illegal dumping is extremely limited because data on the volume or incidents of dumping are scarcely available. Sigman 1998 analyzed the frequency of used oil dumping in the United States. She showed that dumping was sensitive to the cost of legal waste management and the threat of enforcement. Although our research methodology is similar to her, there are several notable differences. First, this paper focuses on a different product, the used electric appliances. The incidents of illegal dumping of used electric appliances are identified more easily and reported more frequently to the regulator as compared with those of used oil. Second, Sigman used a state-level panel dataset, while we use a municipality-level panel dataset. Hence, our analysis can take into account the effects of community characteristics on illegal dumping more precisely. Finally, and most importantly, the agents who carry out illegal dumping are different in the two studies. Sigman analyzed illegal dumping carried out by commercial and industrial enterprises. On the other hand, the illegal dumping of electric appliances studied in this paper is mainly carried out by households.

Since the number of households is far greater than that of enterprises and monitoring of their activity is very costly, it is important to understand how payment-after-use system can induce illegal disposals.

III. Illegal Dumping of Electric Appliances

Since 2001, the Japanese Ministry of the Environment has been conducting surveys that ask municipalities questions regarding the number of incidents of illegal electric appliance dumping and the enforcement strategies aimed at reducing illegal dumping. The report of the survey provides data on televisions, refrigerators, washing machines, and air conditioners that are dumped illegally in each municipality.[5] We calculated the frequency of illegal dumping of these four electric appliances from 2001 to 2003 by dividing the number of incidents by the number of residents.

There are 47 prefectures in Japan, each comprising cities, towns, and villages. There were a total of 3,213 municipalities in Japan as of April 1, 2003. Unfortunately, several municipalities did not maintain a record of the illegal dumping incidents. After eliminating these municipalities from the total number, the number of observations included in our dataset is reduced to 2,978.

Figure 1 shows the geographical distribution of the frequency of illegal dumping summed at the prefecture level. The figure suggests several characteristics of the data. First, the frequency of illegal dumping is larger in the prefectures along the Pacific coast, where the population densities are high. This result would imply that a used appliance might not be transported over a long distance until it is illegally dumped. Second, on an average, the frequency of illegal dumping increased between 2001 and 2003. However, the growth rate of illegal dumping varies among prefectures. In some prefectures, such as Ishikawa Prefecture, the frequency of illegal dumping actually decreased.

Table 1 reports the descriptive statistics of illegal dumping. This table shows that, on an average, 1.396 incidents of illegal dumping are reported per 1,000 residents in a municipality. The variation in the frequency of incidents is large. In some municipalities, illegal dumping incidents are simply not reported. The highest number of incidents in a municipality is 103.333 incidents per 1,000 residents.

Among the four appliances that are dumped, televisions constituted the largest group. The

average frequency of dumping televisions is 0.744. Thus, television dumping incidents account for more than half of the dumping incidents of all the four electric appliances. This result is reasonable when one considers that most Japanese households own only one refrigerator and one washing machine, while some Japanese households own two or three televisions. Moreover, it is considerably easier to dump televisions than other appliances because they are usually smaller and lighter than the other three appliances.

An additional explanation regarding air conditioners would be useful for some readers. Central air conditioning is rarely used in Japan due to the high fuel cost. Many households install air conditioners on the walls of some rooms, but they rarely do so in all rooms. When consumers purchase a new air conditioner from a shop, they usually request the old one to be removed and taken back. It is unreasonable to expect households to remove an old air conditioner from the wall in order to dump it illegally. The additional task discourages households from dumping air conditioners illegally.

IV. Determinants of Illegal Dumping

Explanatory Variable

To investigate the determinants of illegal dumping, we use the frequency of it as a dependent variable and explain its variation by variables that can be summarized into three categories: the expected number of used electric appliances, the cost of legal disposal, and the cost of illegal dumping.

Expected Number of Used Electric Appliances

The Statistics Bureau of Japan undertakes the National Survey of Family Income and Expenditure every five years. In this survey, the number of major durable goods that households possess is estimated at the prefectural level. All four electric appliances (televisions, refrigerators, washing machines, and air conditioners) are included in this survey. We employed the 1999 survey data to represent the potential for generating used electric appliances. The summary of this survey is reported in Table 1 along with the descriptive statistics of other covariates.

We include two additional variables to take into account the difference in the number of used electric appliances at the municipality level. The households in high-income municipalities will possess more electric appliances and will purchase new ones more frequently. Thus, it is expected that the generation of used electric appliances is higher in municipalities with a high-income population.[7]

Size of household size may affect the behavior with regard to the management of old electric appliances. The cost of storing it is high for households residing in small houses; they find it difficult to create space for old electric appliances. In order to take into account the storage cost of old electric appliances, we include population density in the analysis. The data is obtained from the population census (Japanese Ministry of Internal Affairs and Communications 2000).

Cost of Legal Disposal

Households take used electric appliances to a retailer or ask the retailer to collect them. They pay recycling and transportation fees to the retailer. The retailer has to take the used appliances to the collection depot. As we explained in the previous section, most manufactures charge identical recycling fees. In contrast, the transportation fee varies among retailers. Unfortunately, the data on transportation fees is not available. We estimate the distance from each municipality to the nearest collection depot and use it as the transportation fee. The longer the distance to the nearest depot is, the higher the transportation cost will be. Hence, we expect that the frequency of dumping will increase as the distance increases.

We used Logistica Truck II to estimate the distances. It is the software popularly used among Japanese transportation companies and shows the shortest path to the destination. It includes the road map inside and simulates the distance between two locations. Both Group A manufactures and Group B manufacturers have 190 collection depots. For each group, we estimated the distance between a municipality and all 190 collection depots. Then we found the nearest collection depot for each municipality. For the municipalities that have collection depot within their boundary, we assume the distance is zero. The average distance to the nearest collection depot of Group A is 15.56 miles and that of Group B is 15.94 miles.

The financial burden of the legal disposal cost depends on the income level of the household. For high-income households, the financial burden is not significant. For low-income households, the financial burden is high. Income increase reduces illegal dumping in this respect, while it increases the expected number of used appliance as examined in the previous section. Overall effect of income increase is ambiguous and needs to be resolved empirically.

Similarly, the financial burden of legal disposal will be large for an unemployed person. Thus, the local labor market condition may have an impact on the frequency of illegal dumping. While considering this issue, we include the unemployment rate in the analysis. We expect that an increase in the unemployment rate will lead to an increase in illegal dumping. We use the unemployment data obtained from the population census.

Retailers can refuse to collect certain products, such as a product that was manufactured by a liquidated company. Some municipalities collect these “orphan products” as a public service. The provision of the public collection service will reduce the legal disposal cost. We include a dummy variable for the availability of the public collection service. This data is taken from the survey conducted by the Ministry of the Environment.

Expected Cost of Illegal Dumping

Geographical conditions will also influence the frequency of illegal dumping. It is easy to find a site to conduct illegal dumping if open space in the municipality is abundant. To take into account the effect of the geographical conditions, we include the ratio of the municipality’s residential area to its total area. We call this ratio the residential area rate. The cost of searching a dumping site is high if this ratio is high. Hence, we expect the coefficient of this variable to have a minus sign.

The expected cost of illegal dumping depends on the detection probability of illegal dumping and the imposition of the penalty. The penalty is basically determined by national law and is uniform across the municipalities. In the subsequent analysis, we will only focus on the difference in the detection probability.

The clearance rate for crimes under the penal code can be used to measure the general

enforcement level of a municipality. The source of this data is Keisatsu Hakusho (National Police Agency 2000). The detection probability of illegal dumping will be high in a municipality with a high clearance rate. In such a municipality, the expected cost of illegal dumping increases to a high level. We expect a minus sign for the coefficient.

Other Explanatory Variables

There are some studies that examine whether environmental outcomes are influenced by community characteristics. Hamilton (1995) and Arora and Cason (1999) examined whether the share of the minority population in a local community influenced the environmental outcome in the United States. Hamilton concluded that the capacity expansion decision of commercial hazardous facilities is not explained by the share of the minority population, but by the estimated voting rate. Hence, he argued that collective action explains the relationship between race and environmental conditions. On the other hand, Arora and Cason concluded that the toxic release pattern in 1993 is explained by the share of the minority population, and not by the estimated voting rate. Thus, they argued that racial discrimination may be significant.

Pargal and Wheeler (1996) examined the effects of community characteristics on facility-level industrial wastewater discharges in Indonesia and concluded that the community informally influenced the abatement activities of local facilities. However, they suggested that the education level of the local community can influence the effectiveness of such informal regulation.

Earnhart (2004) studied the compliance level of the effluent limit of municipal wastewater treatment facilities in the state of Kansas in the United States. He found that that community characteristics influenced the compliance level even after he controlled the enforcement by the government in the estimation.

All the studies reveal that community characteristics influence the environmental outcome. In order to take this perspective into account, we include several additional variables. We include the homeowner rate and voter turnout to examine the impact of collective action on the prevention of illegal dumping. The data on the homeowner rate is obtained from the population census. For the voter turnout, we use the data on the proportion of the voting-age population that voted in the 1998

House of Councilors' Election; this data is sourced from the Network Democracy Forum (2002). As an index of the education level, we use the percentage of residents who graduated either from a junior college or a university; this data is sourced from the population census.

Empirical Model

The number of the illegal dumping incidents is zero in many municipalities. Therefore, we consider Tobit model for the evaluation of the determinants of illegal dumping:

$$y_i = \alpha + \boldsymbol{\beta}\mathbf{X}_i + u_i \qquad \text{if} \quad RHS > 0$$

$$y_i = 0 \qquad \text{otherwise.}$$

y_i is the number of illegal appliance dumping incidents per 1,000 residents. Since most explanatory variables of $\mathbf{X}_i$ are the data of the single year, we apply the dumping incidents in 2003 for the explained variable. To take into account the potential heterogeneity, we adopt an estimation weighted by population.

Results

Group A's designated collection site is often located in the municipality where Group B's designated collection site is located. To avoid a multicolinearity problem, we estimated the effect of the transportation cost between two groups separately. Table 2 and Table 3 report the estimation result of Group A and Group B, respectively.

The first column shows the result when the total number of illegal dumping incidents of all four electric appliances is taken as a dependent variable. The remaining four columns show the results when the dumping incident of the specified electric appliance is taken as a dependent variable.

The results of the two tables produce several insights. First, two tables offer the very similar results although the parameter values are slightly different. Second, within the same table, the five models offer the same parameter signs for most variables.

All coefficients for transportation cost variables take positive signs and it is statistically

significant when refrigerator and washing machine are used for a dependent variable. This implies that the frequency of illegal dumping increases as the transportation cost increases. We find that an increase in the unemployment rate has a positive impact on illegal dumping. Illegal dumping occurs in municipalities with a higher unemployment rate. The frequency of illegal dumping is lower in municipalities where public collection services are provided. This is because the legal disposal cost is lower in these municipalities. These results support the economic theory discussed in the previous literature: the frequency of illegal dumping incident increases as the legal disposal cost rises.

The income increase has a negative impact on the number of illegal dumping incidents. As discussed earlier, the income increase produces two counter effects. While wealthy households may generate more used electric appliances, they dispose of them appropriately. The result indicates that the latter effect is stronger.

The clearance rate for crimes under the penal code influences the frequency of illegal dumping. The minus sign for the coefficient of this variable supports our explanation. Municipalities with a high clearance rate have a high enforcement level. Therefore, the cost of carrying out illegal dumping is high in such municipalities. We find that the frequency of illegal dumping is lower in such municipalities.

A higher voter turnout results in a lower frequency of illegal dumping. If we assume that this variable measures the level of collective action as measured in the previous studies, the result implies that collective action reduces the incidents of illegal dumping. However, based on the estimation result, its contribution to the reduction of dumping is modest.

V. Effectiveness of Enforcement Activities

Classification of Enforcement Activities

In order to reduce illegal dumping, municipalities have conducted various enforcement activities. The objective of this section is to evaluate the effectiveness of these enforcement activities. The Japanese Ministry of the Environment conducted a survey on these enforcement activities. Since the enforcement data of some municipalities are not available, only 2,911 municipalities (90.6% of all municipalities) are included in the subsequent analysis.

In the survey, enforcement activities are classified into eight categories. Table 4 summarizes the adoption of these enforcement activities. The numbers in the table show the percentage of municipalities that adopted each enforcement activity. A comparison of the adoption rate shows that the municipalities strengthened the enforcement activities between 2001 and 2003.

In some municipalities, city officers engage in patrols, while in other municipalities, patrols are contracted out to private companies. If municipalities conduct some patrols, the patrol variable takes one; otherwise, it takes zero. Based on the survey, 62.73% of the municipalities engaged in patrols in 2003. Municipalities occasionally install a surveillance camera at the site where illegal dumping occurs frequently. The survey shows that 3.95% of the municipalities have installed surveillance cameras.

An explanation of the new recycling system and education of the residents may contribute to the reduction of illegal dumping. Many municipalities display the relevant information at public facilities and distribute leaflets to the residents. Roughly half of the municipalities spend their budget on these education activities.

An illegal dumping invites subsequent illegal dumping. People tend to dump their used appliance at the site where a used appliance has already been dumped before. Therefore, it is important to find the dumping incidents at an early stage. Municipalities ask various organizations to report illegal dumping incidents in order to prevent further aggravation of the situation. These organizations include local residents, the post office, taxi companies, and the police.

Empirical Model

In Section 2, we found that the frequency of illegal dumping increased between 2001 and 2003. However, the growth rate varies among municipalities. If the enforcement activities are effective for the prevention of illegal dumping, we expect that the growth rate in the municipality with enforcement activities becomes lower than that without them.

The range of the reduction of illegal dumping depends on the initial level of illegal dumping. If the number of illegal dumping incidents in 2001 is 3, then the maximum reduction between 2001 and 2003 is 3. In order to take the status quo effect into consideration, we evaluate the

following likelihood function:

$$\ln L(\beta) = \sum_i I_0 \cdot F\left(0 \middle| Z_i^{2001}, \mathbf{X}_i^{2001}, \boldsymbol{\beta}\right) + \sum_i I_1 \cdot f\left(\Delta y_i \middle| Z_i^{2001}, \mathbf{X}_i^{2001}, \boldsymbol{\beta}\right),$$

where Δy_i is the change in the illegal dumping incident between 2001 and 2003. Z_i^{2001} is the dummy variable that takes 1 if the municipality adopted a specific enforcement activity in 2001. X_i^{2001} is the vector of other variables. $\boldsymbol{\beta}$ is the vector of the parameters.

The first term on the right hand side equation corresponds to the case when the number of illegal dumping incidents in 2003 is zero. $F(\cdot)$ is the cumulative density function and measures the probability that the number of illegal dumping incidents in 2003 becomes non-positive. In contrast, the second term corresponds to the case when the number becomes positive. $f(\cdot)$ is the probability density function that the change in the illegal dumping incidents becomes Δy_i. I_0 and I_1 are the index variables that take 1 in the corresponding case and take 0 otherwise.

Results

Results are shown in Table 5. The average change of illegal dumping incidents $\overline{\Delta y}$ is 0.52919. Since our likelihood function is a complicated form, we only include four control variables in the estimation. Those are log of income, unemployment rate, education level, and clearance rate.

The surveillance and report systems established in cooperation with the local residents, post offices and/or taxi companies, and police authorities contribute to the reduction of illegal dumping. For example, the establishment of the surveillance system in cooperation with the post office and/or taxi companies has reduced the incidents by 0.26162. Thus, the surveillance system is effective.

We obtained the opposite sign for the income variable. In both Table 2 and Table 3, we observed a minus sign for the income variable. It means that the frequency of illegal dumping is lower in high-income communities. On the other hand, in Table 5, we observed a positive sign for the income variable. This result implies that the growth rate of illegal dumping is higher in high-income municipalities.

The signs for the remaining control variables are the same as those in Table 2 and Table 3. Therefore, the situation of illegal dumping has been further aggravated in municipalities that already had a high level of the incidents. For example, in municipalities with a high unemployment rate, the frequency of illegal dumping was high in 2001. In such municipalities, the growth rate of illegal dumping is relatively higher.

VI. Conclusion

The attractiveness of unit pricing programs crucially depends on the extent of illegal dumping. In this study, we have used unique dataset to estimate the effect of unit pricing programs on illegal dumping. We found that the situation of illegal dumping is deteriorating over time. This might suggest that the unit pricing programs have a negative consequence.

The frequency of illegal dumping is well explained by economic conditions. The frequency of illegal dumping increases as the legal disposal cost and decreases as the cost of illegal dumping rises. Community characteristics greatly influence the marginal effect of a unit pricing program on illegal dumping. The frequency of illegal dumping is higher in a low-income community with a high unemployment rate. In order to reduce illegal dumping, the municipalities conducted various enforcement activities. We evaluated their effectiveness and found that the surveillance and reporting systems established have contributed to the reduction of illegal dumping. This points to the importance to find dumping incidents at an early stage.

Notes

1. See Fullerton and Kinnaman (1996) and Kinnaman and Fullerton (2000).
2. The target for recycling is determined by weight: 55% for televisions, 50% for refrigerators and washing machines, and 60% for air conditioners.
3. This program is said to have adopted the concept of extended producer responsibility; each producer is responsible for financing the collection, treatment, recovery, and environmentally sound disposal of WEEE. The program further prohibits revealing waste treatment costs to consumers at the time of selling new products.

4. We convert 120 yen into 1 dollar in this paper. The company that transfers recycling of the product to another company charges a slightly higher recycling fee. Three companies charge 4,714 yen and one company charges 15,000 yen for air conditioners. Fifteen companies charge 5,569 yen and one company charges 5,670 yen for refrigerators. Five companies charge 3,444 yen for washing machines.
5. In Japan, municipal solid waste is classified into household waste and business waste. Household waste can be further classified into general garbage and bulky garbage.
6. The report only provides the summary statistics. We requested the Ministry of the Environment of Japan for offering municipality-level data on illegal dumping.
7. The source of income data is Kojin Shotoku Shihyo (Nihon Marketing Kyoiku Center 2000).

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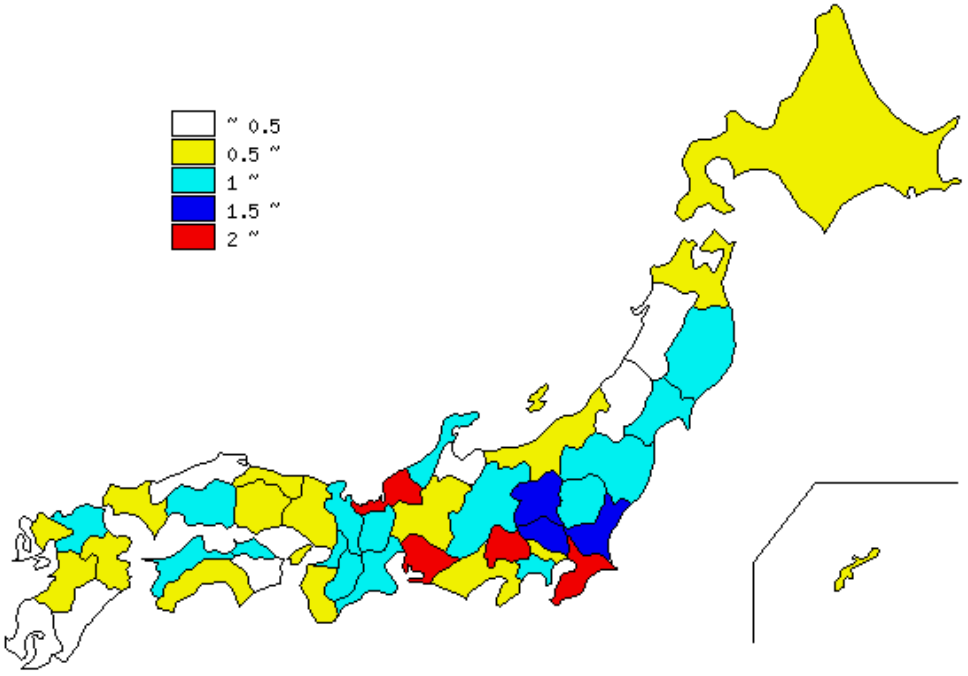

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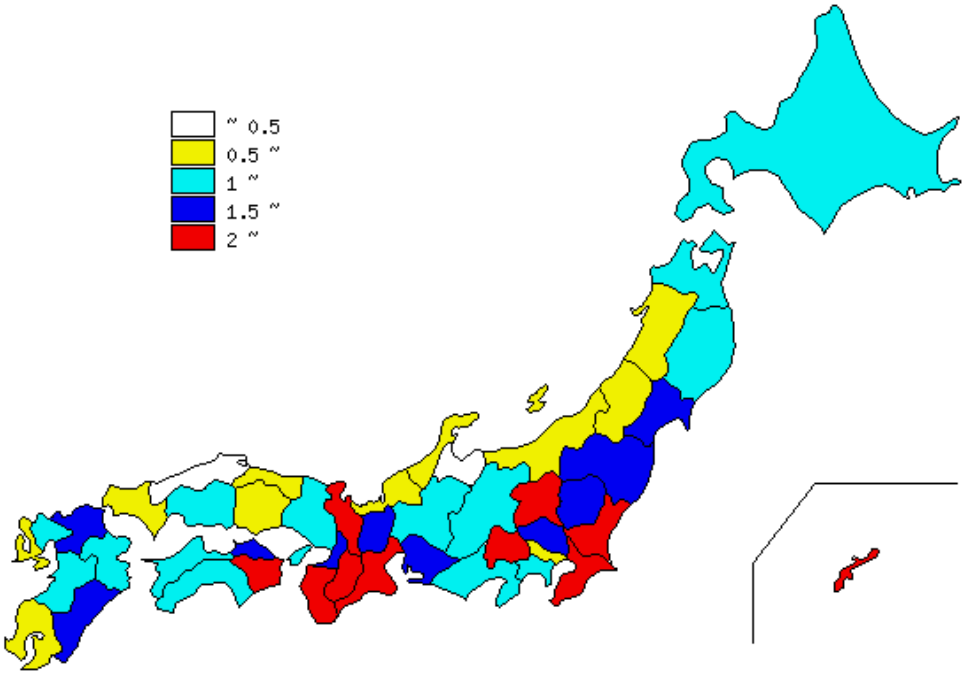

Year 2003

Figure 1. Nubmer of Illegal Dumping Incidents per 1,000 Residents

Table 1.

Descriptive Statistics

	Units	Data Level	Mean	Std[a]	Min	Max
Number of illegal dumping incidents per 1000 residents						
All Four Appliances	Cases	Municipality	1.396	2.794	0	103.333
Air Conditioner	Cases	Municipality	0.099	0.310	0	12.4242
Television	Cases	Municipality	0.744	1.363	0	47.7778
Refrigerator	Cases	Municipality	0.300	0.793	0	34.0776
Washing Machine	Cases	Municipality	0.253	0.723	0	33.3333
Number of appliances owned per 1000 residents						
All Four Appliances	Units	Prefecture	6679.865	1014.776	4345.000	8528.000
Air Conditioner	Units	Prefecture	1856.323	781.984	109.000	2971.000
Television	Units	Prefecture	2367.553	281.985	1454.000	2978.000
Refrigerator	Units	Prefecture	1333.374	107.571	1144.000	1542.000
Washing Machine	Units	Prefecture	1122.615	57.114	1031.000	1265.000
Log of Income	Million Yen	Municipality	1.126	0.130	0.806	2.080
Population Density	Persons/100 km^2	Municipality	74250	181354	155	1985413
Education Level	%	Prefecture	22.876	5.230	14.843	38.791
Unemployment Rate	%	Municipality	3.838	1.569	0.000	15.782
Voter Turnout	%	Municipality	66.574	9.430	35.480	98.150
Homeowner Rate	%	Municipality	79.539	13.167	13.883	99.396
Residential Area Rate	%	Municipality	47.462	29.981	2.129	100.000
Arrest Rate	%	Prefecture	27.558	8.122	14.400	48.800
Group A	Km	Municipality	25.267	17.988	0	141.902
Group B	Km	Municipality	23.914	16.705	0	140.454

Note. [a]: Standard deviation

Table 2.

Determinants of Illegal Dumping of Appliances: Group A Result (N = 2978)

Variables	All Four Appliances	Air Conditioner	Television	Refrigerator	Washing Machine
Constant	3.3748***	0.3453***	2.0022***	−0.0506	−0.0530
	（0.6251）	(0.1135)	(0.3074)	(0.2103)	(0.2292)
Expected Number of Used Electric Appliances					
Number of Appliances	0.0001***	0.0001***	−0.0001**	0.0006***	0.0007***
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)
Log of Income	−1.1969***	−0.0602	−0.5030***	−0.1506**	−0.1987***
	(0.2963)	(0.0561)	(0.1531)	(0.0742)	(0.0697)
Population Density	5.29E-07***	2.02E-07***	-5.65E-08	2.67E-07***	1.16E-07***
	(1.14E-07)	(2.13E-08)	(5.86E-08)	(2.86E-08)	(2.66E-08)
Cost of Legal Disposal					
Transportation Cost	0.0074***	0.0005	0.0012	0.0023***	0.0016***
	(0.0024)	(0.0005)	(0.0013)	(0.0006)	(0.0006)
Unemployment Rate	0.1728***	0.0536***	0.0409***	0.0620***	0.0432***
	(0.0240)	(0.0045)	(0.0123)	(0.0064)	(0.0058)
Public Collection	−0.1578**	−0.0899***	−0.0552*	−0.0212	−0.0062
	(0.0614)	(0.0115)	(0.0316)	(0.0153)	(0.0143)
Expected Cost of Illegal Dumping					
Residential Area Rate	0.0005	−0.0001	−0.0001	−0.0001	0.0006*
	(0.0014)	(0.0003)	(0.0007)	(0.0004)	(0.0003)
Clearance Rate	−0.0522***	−0.0081***	−0.0189***	−0.0158***	−0.0124***
	(0.0041)	(0.0008)	(0.0021)	(0.0010)	(0.0010)
Other Covariates					
Education Level	−0.0198***	−0.0100***	−0.0024	−0.0019	0.0002
	(0.0067)	(0.0013)	(0.0035)	(0.0018)	(0.0017)
Homeowner Rate	0.0018	−0.0002	0.0010	0.0003	0.0003
	(0.0015)	(0.0003)	(0.0008)	(0.0004)	(0.0003)

Table 2.
Continued

Voter Turnout	−0.0074	−0.0031***	−0.0043	−0.0029**	−0.0035***
	(0.0055)	(0.0011)	(0.0028)	(0.0014)	(0.0013)
Sigma	1.3965***	0.2571***	0.7212***	0.3481***	0.3244***
	(0.0184)	(0.0036)	(0.0096)	(0.0047)	(0.0044)
Log Likelihood	−5158.1010	−430.6145	−3248.0250	−1181.5410	−991.4756

Note. The numbers in parentheses indicate standard deviations

* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

A E-07 = A × 0.0000001, A E-08 = A × 0.00000001.

Table 3.

Determinants of Illegal Dumping of Appliances: Group B Result (N = 2978)

Variables	All Four Appliances	Air Conditioner	Television	Refrigerator	Washing Machine
Constant	3.2654***	0.3341***	1.9586***	−0.1031	−0.0840
	(0.6261)	(0.1138)	(0.3082)	(0.2107)	(0.2294)
Expected Number of Used Electric Appliances					
Number of Appliances	0.0001***	0.0001***	−0.0001**	0.0006***	0.0007***
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)
Log of Income	−1.0967***	−0.0482	−0.4561***	−0.1211	−0.1806**
	(0.2993)	(0.0568)	(0.1548)	(0.0749)	(0.0704)
Population Density	5.23E-07***	2.02E-07***	-5.80E-08	2.65E-07***	1.15E-07***
	(1.14E-07)	(2.12E-08)	(5.86E-08)	(2.86E-08)	(2.66E-08)
Cost of Legal Disposal					
Transportation Cost	0.0102***	0.0009	0.0028**	0.0031***	0.0021***
	(0.0027)	(0.0005)	(0.0014)	(0.0007)	(0.0006)
Unemployment Rate	0.1846***	0.0547***	0.0449***	0.0659***	0.0456***
	(0.0243)	(0.0046)	(0.0125)	(0.0065)	(0.0058)
Public Collection	−0.1683***	−0.0908***	−0.0579*	−0.0240	−0.0081
	(0.0613)	(0.0115)	(0.0316)	(0.0152)	(0.0143)
Expected Cost of Illegal Dumping					
Residential Area Rate	0.0005	−0.0001	0.0000	0.0000	0.0006**
	(0.0014)	(0.0003)	(0.0007)	(0.0004)	(0.0003)
Clearance Rate	−0.0504***	−0.0079***	−0.0183***	−0.0152***	−0.0120***
	(0.0041)	(0.0008)	(0.0021)	(0.0011)	(0.0010)
Other Covariates					
Education Level	−0.0217***	−0.0102***	−0.0030	−0.0024	−0.0002
	(0.0067)	(0.0013)	(0.0036)	(0.0018)	(0.0017)
Homeowner Rate	0.0017	−0.0003	0.0010	0.0003	0.0003
	(0.0015)	(0.0003)	(0.0008)	(0.0004)	(0.0003)

Table 3.
Continued

Voter Turnout	−0.0087	−0.0033***	−0.0051*	−0.0033**	−0.0037***
	(0.0055)	(0.0011)	(0.0028)	(0.0014)	(0.0013)
Sigma	1.3952***	0.2569***	0.7207***	0.3476***	0.3242***
	(0.0184)	(0.0036)	(0.0096)	(0.0047)	(0.0044)
Log Likelihood	−5155.5650	−429.7990	−3246.4750	−1178.0560	−990.0349

Note. The numbers in parentheses indicate standard deviations

* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level

A E-07 = *A* × 0.0000001, *A* E-08 = *A* × 0.00000001.

Table 4.

Enforcement Activities Adopted by Municipalities (N = 2911)

Variables	Description of Measures	Percentage of municipalities adopting enforcement activities	
		Year 2001	Year 2003
Patrol	Patrols by city officers and/or commissioned contractors	54.38%	62.73%
Surveillance Cameras	Installation of a surveillance camera	1.51%	3.95%
Education	Provision of education to the local residents through posters, leaflets, and signboards	38.89%	48.06%
Resident Support	Surveillance and report systems in cooperation with the local residents	27.55%	31.60%
Post Office Support	Surveillance and report systems in cooperation with post offices and/or taxi companies	23.15%	40.43%
Police Support	Surveillance and report systems in cooperation with the police authorities	14.36%	16.45%
Subsidy	Subsidies on recycling fees	0.69%	0.55%
---	Other measures	5.77%	3.98%

Table 5.

Effectiveness of Enforcement Activities (N = 2911)

Variables	Type of Enforcement Activity							
	None	Patrol	Surveillance Cameras	Education	Resident Support	Post Office Support	Police Support	Subsidy
Enforcement in 2001		−0.02157	−0.03216	−0.02470	−0.08296***	−0.26161***	−0.13667***	0.18669
		(0.02207)	(0.02334)	(0.02656)	(0.03055)	(0.02314)	(0.14053)	(0.18657)
Control Variables								
Log of Income	0.07543***	0.07834***	0.07771***	0.07752***	0.07864***	0.08976***	0.07525***	0.07486***
	(0.02477)	(0.02488)	(0.02506)	(0.02478)	(0.02483)	(0.02486)	(0.02481)	(0.02478)
Unemployment Rate	0.07597***	0.07642***	0.07642***	0.07615***	0.07729***	0.08741***	0.07649***	0.07627***
	(0.00665)	(0.00665)	(0.00666)	(0.00666)	(0.00666)	(0.00670)	(0.00670)	(0.00666)
Education Level	−0.00159	−0.00147	−0.00158	−0.00155	−0.00164	−0.00046	−0.00145	−0.00162
	(0.00291)	(0.00291)	(0.00291)	(0.00292)	(0.00291)	(0.00294)	(0.00291)	(0.00291)
Clearance Rate	−0.00701***	−0.00708***	−0.00702***	−0.00711***	−0.00708***	−0.00779***	−0.00711***	−0.00702***
	(0.00133)	(0.00133)	(0.00133)	(0.00133)	(0.00132)	(0.00135)	(0.00133)	(0.00133)

Note. The numbers in parentheses indicate standard deviations

* Significant at the 10% level ** Significant at the 5% level *** Significant at the 1% level