DOES GARBAGE PRICING INCREASE ILLEGAL DUMPING OF HOUSEHOLD WASTE?

Takehiro Usui *†   Mitsuko Chikasada

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Abstract

Although many theoretical studies have tried to clarify the mechanism of how illegal dumping would arise, there have been no empirical papers directly examining whether garbage pricing increases illegal disposal. Some indirect approaches do not seem to be reliable in term of survey design and estimation strategy for the following reasons: firstly, they did not control endogeneity problems. Secondly, there is a problem when data depends on human sense in indirect approaches. For example, report-based data from a citizen will increase if the citizen believes illegal disposal is deeply problematic. Thirdly, there will be another type of endogeneity, the relationship between crime reporting and police (Levitt, 1998). To overcome the indirect and direct measurement problems, we take notice of the nature of natural experiment, and apply spatial econometrics (Anselin, 1988). Considering those assumptions, we apply spatial econometric approach, spatial lag of X (SLX) model. Specifically, we assume the exogeneity of neighboring municipalities' pricing decision, and use the model that considers the exogeneity of illegal dumping due to introducing garbage pricing. The major findings of the present study is that there is illegal dipsosal relative to the fixed pricing and two-tier pricing.

JEL classification: C23, H23, K42, Q53

Key words: Garbage pricing, Waste reduction, Difference-in-Differences (DID), Spatial econometrics, Illegal dumping of household waste

* *Corresponding author*: Takehiro Usui, Faculty of Economics, Soka University, 1-236, Tangi-cho Hachioji, Tokyo 192-8577, Japan.

† *Tel:* +81(42)691-4016; *Fax:* +81(42)691-8232; *E-mail:* usui@soka.ac.jp

1 Introduction

Many municipalities have introduced garbage pricing policy in order to reduce household solid waste. Concretely, garbage pricing means that users pay for municipal waste collection services per unit of waste collected, known as unit-based pricing (UBP), which is a method called “pay per bag” or “pay-as-you-throw (PAYT)”. However municipalities which have not introduced garbage pricing are anxious about whether illegal dumping would increase by garbage pricing. Although many theoretical studies have tried to clarify the mechanism of how illegal dumping would arise, there have been no empirical papers directly examining whether garbage pricing increases illegal disposal. Therefore we are trying to clarify whether garbage pricing increases illegal dumping, shedding light on the nature of natural experiment hiding in the Japanese municipal solid waste data.

Previous studies have tackled the problem of household illegal dumping with indirect approaches. Kinnaman and Fullerton (1996), Yamakawa *et al*.(2002), and Kim *et al*.(2007) used the data based on complaints from citizens, or questionnaire survey to the people who engage in the section of waste management in municipality as proxy for the amount of illegal waste. They concluded garbage pricing increases illegal dumping.

In spite of statistically significant evidence in those studies, their indirect approaches do not seem to be reliable in term of survey design and estimation strategy for the following reasons: Firstly, they did not control endogeneity problems. Endogeneity problems arise when introduction of garbage pricing is correlated with the degree of environmental consciousness of citizens in municipality. If municipalities believe that environmental conscious citizens do not dispose illegally, municipalities are willing to introduce garbage pricing, but are not willing to introduce garbage pricing where environmental unconscious citizens are living in there. Thus comparing the average values between garbage pricing introduced municipality and not introduced will be problematic.

Secondly, there is a problem when data depends on human sense in indirect approaches. For example, report-based data from a citizen will increase if the citizen believes illegal disposal is deeply problematic. However it may depend on individual status, such as income, academic background and also environmental consciousness.

Thirdly, there will be another type of endogeneity, the relationship between crime reporting and police (Levitt, 1998). It is a type of problem that crime reporting behavior is also affected by the policy. If the municipality gets at the information of illegal disposal from a citizen’s report, municipality will increase the number of police to detect. The effect will bring about a decrease in illegal disposal, and finally citizens’ report will decrease, however the treatment of increasing the number of staff is dependent of its municipal budget. To sum up, to estimate the effect of the introduction of garbage pricing on illegal disposal in an indirect way causes a lot of biases.

Meanwhile, how about directly measuring the amount of collected illegally disposed waste? However there are also non-negligible problems. Firstly, since there is financial restriction in municipality, illegal waste collection highly depends on its municipal budget. Secondly, as a nature of illegal disposal, it is difficult to grasp and detect the true amount of illegal waste. Therefore more or less there is severe sampling bias of directly collected data.

To overcome the indirect and direct measurement problems, we take notice of the nature of natural experiment, and apply spatial econometrics (Anselin, 1988). Here we show the brief explanation about estimation strategy. Firstly, we focus on the side of the fact that illegal disposal is partly collected by the private company when it is dumped in the garbage box set on the convenience store. Since this type of waste data, which is called as office waste, is integrated with the amount of collected household waste to finally become the total municipal solid waste, we can get illegal disposal data including in the amount of municipal solid waste.

Secondly illegal disposers can safely dispose their waste by throwing in the bin set at convenience stores without doing illegal dumping in prohibited place. In other words, the best strategy to avoid paying priced bag is to throw waste in convenience store. Normally, if there is convenience stores near his/her living place, they throw it on the nearest store assuming the transportation cost and punishment cost by illegal waste disposing. Therefore it is natural presumption that illegal disposal will occur at the near convenience store's bin in the municipalities that have already introduced garbage pricing, but will little occur in those that have not introduced it, when other factors are controlled.

Considering those assumptions, we apply spatial econometric approach, spatial lag of X (SLX) model. Specifically, we assume the exogeneity of neighboring municipalities' pricing decision, and use the model that considers the exogeneity of illegal dumping due to introducing garbage pricing.

The paper is organized as follows. The next section describes the spatial econometric model employed and the type of data used. Next, Section 3 presents a detailed report of the estimation results. The final section contains the concluding remarks.

2 Data and Model

In this section we show our estimation strategy to estimate the spatial externalities arising from neighborhood municipal policy charactericstics in the form of directly waste dumping in a garbage bin at the store to avoid paying priced bag. We estimate the demand curve of waste collection service using municipal waste data. Here We show the estimation model, and the dependent and independent variables. Finally we explain our data.

2.1 Spatial lag of X (SLX) model

We employ a spatial regression model of a spatiotemporal analysis proposed by LeSage and Pace (2009) in order to specify the effect of the garbage pricing policy on household demand for waste collection service. We will capture the spillover effect like a natural experiment, because we can see whether or not there are effects from adjacent municipalities when other factors are set constant. Though the assignment of introduction of pricing is not random, we use spatial econometrics on Difference-in-Differences (DID) approach, and can simultaneously control for endogeneity problems, such as unobserved heterogeneity, and spatial spillover effect. In this way, we can overcome to correct the bias caused by the spatial dependency problem, such as spatial lags of neighboring pricing characteristics, where w_{ij} and x_{jt} are a component of spatial weight matrix, $n \times n$ reflecting the connectivity structure of the municipalities and the vector of dummy variables for garbage pricing, respectively. $\sum_{j=1}^{n} w_{ij}x_{jt}$ means the number of adjacent municipalities that have introduced each garbage pricing policy for municipality i at t in below equation,

$$y_{it} = x_{it}\beta + \sum_{j=1}^{n} w_{ij}x_{jt}\rho + z_{it}\gamma + \alpha_i + \lambda_t + \epsilon_{it}. \tag{1}$$

where the dependent variable, y_{it}, is the natural log of the amount of waste generation per capita per day (grams) of the i-th municipality in year t, z_{it} is vector of other demographic variables (natural log) that have an influence on waste generation. α_i and λ_t are the unobserved heterogeneity that are invariant across time and cross-section change, respectively. We define this ρ is a spillover effect which is affected by affected by the illegal behavior of disposer from neighboring municipality that has introduced some type of garbage pricing policy, and β is a direct effect of garbage pricing. γ is parameter vectors in this demographic variables. By means of weight matrix we expect to capture the external effect of adjacent municpal change of garbage pricing . We assume the error term ϵ is normally independently distributed with mean as 0, and variance σ^2 is constant. To estimate the parameters, we use Ordinary Least Squares (OLS).

2.2 Explaining variables

We describe the explaining variables, such as dummy variables for garbage pricing and other demographic variables. At first, we define the dummy variables for garbage pricing. There are three types of garbage pricing policy in Japan, such as the unit-based pricing (UBP), two-tier pricing, and fixed charge pricing. As is supported by many studies, the introduction of bag price (UBP, two-tier pricing) will decrease household waste because it places the burden of waste emission on the citizens and encourages them to refuse too much lapping in store (eg. Kinnaman and Fullerton, 2000; Dijkgraaf and Gradus, 2009; Allers and Hoeben, 2010). On the other hand, fixed pricing does not change people's actions because the economic burden is the same for any volume of waste. We transform these categories as dummy variable of whether municipality introduces its pricing method [1].

[1]Though prior studies in Japan such as, Yamaya (2007) and Usui (2008) collected more rich bag-price data, we cannot use them because those data include only some large city data or data only for single year, respectively. Since both data do not satisfy adjacent and panel conditions simultaneously, we avoid using those data, and only use the pricing dummy variables.

Second, we explain the other demographic variables, which have been employed in prior studies on garbage pricing: the income per capita, the population density, the household size, and age structure. $\ln$ *Popd* represents the population density (persons/mile). This variable will be proxy as scarcity of land space, and decreasing waste generation by composting at backyard waste if population density decreases. $\ln$ *Income* is the income per capita but proxied by taxable gain per capita (dollars). They capture the proxy of amount of consumption and environmental consciousness to reduce / refuse plastic bags or packaging waste. $\ln$ *Family*, the household size, may include a scale merit of consumption, because a large household size will exhibit increased household consumption but decreased per capita consumption of, for example, shared goods such as newspapers. Further, *Over 65* represents the ratio of people aged over 65 to total municipal population, and capture the household character of old persons.

2.3 Data Sources

We marge two kinds of municipal panel data, such as waste data and demographic data. Here we show the data source and its size.

First, we explain the municipal waste (dependent variable) and UBP data, which includes all municipalities in Japan (about 3200 municipalities) and was obtained from Japan Waste Management Association (1998-2002). We made its panel data pertaining to the waste generations for each municipality spanning an five-year period from fiscal years 1998 to 2002 [2]. Second, other demographic data is obtained from Asahi Shinbun (2003), which is a collective database containing data for all municipalities. We exclude any outliers and missing values, and the final data used in our estimation becomes 2951 (municipalities) $\times$ 5 (years) balanced panel data.

In addition, we make spatial weights matrix based on a queen contiguity criterion. W is a 2951×2951 matrix. The element (i, j) of W is set equal to one if municipalities i and j share border or vertex, and zero otherwise [3].

The descriptive statistics and the definitions of the variables are presented in Table 1. Table 1 shows the status of the pricing method for the municipalities that had introduced UBP in Japan. The most popular method of pricing waste is unit-based pricing by bag: 29% of municipalities had introduced this method in Japan (pooled sample mean for 5 years). The second most popular method is fixed pricing (16%), and the third one is two-tier pricing (3%). 52% of municipality does not introduce any pricing method.

[2] There were the municipal mergers after 2002. By using the data just up to 2002, we can set aside the effect of the municipal mergers.

[3] We do not use a row standardized matrix, in which the elements of each row add up to one, because it is more clear for using non-standardized matrix to represent the spillover effect per municipality

3 Estimation Result

We estimate non-spatial and SLX model for each three panel models, pooled OLS, fixed effect model (FEM) and random effect model (REM), respectively. First of all judging by the results of the test statistics of model selection, we only consider FEM estimates (Table 2) [4]. Second, we test the model validation of SLX model of FEM. In order to check the model varidation, we compare the both R^2s. R^2 of SLX is larger than non-spatial one. In addition, we check F value in lag of X that is set with null hypothesis that $H_0 : \rho = 0$ for all coefficents, and the estimation result shows that each F value of models is $F(3, 2950) = 5.38$, statistically significant for $p = 0.0011$. Therefore we make judgment to use SLX model rather than non-spatial one. Standard errors in the FEMs are corrected for heteroscedasticity. Here we explain only SLX model (second column in Table 2).

The coefficient of UBP (D_{ubp}) is significant at the 1% level and negative, as expected. Since all estimations are in natural logs, the coefficients of dummies are calculated as $e^x - 1$ with x the coefficients (Wooldridge, 2008). The UBP decreases 2.235% ($= e^{-0.0226} - 1$) of total waste less than those which have not on average. A coefficient of $W \times D_{ubp}$ in SLX is not statistically significant. Therefore we cannot find evidence of illegal disposal on unit-based pricing.

We find evidence of illegal dipsosal in another type of garbage pricing, D_{fix}, which is a dummy variable for the introduction of fixed pricing. On average, the total municipal waste is 2.000% less if there are no neighboring municipalities around it. Since there is no economic incentive to reduce waste, people might be affected by something like a non-pecuniary motivation. A coefficient of $W \times D_{fix}$ in SLX model is statistically significant and positive. The coefficient shows 0.575% increasing per one adjuscent municipality introduced the fixed pricing. To sum up, we interpret that a part of reduction on total waste by fixed pricing in a municipality induces illegal disposal.

We also find evidence of illegal dipsosal relative to the D_{fem}, which is a dummy variable for the introduction of two-tier pricing. The coefficient of D_{fem} is not statistically significant. However spillover effect of two-tier pricing is highly statistically significant and positive, increasing 1.238% of total waste to neighboring municipality. Since the municipality introduced two-tier pricing is provided a certain amount of free charged bags by municipality, people may feel burden to buy charged bags, and dispose illegally. Thus the coefficient of D_{fem} is canceled out, and the coefficient of D_{fem} may not be significant.

Next we show the estimation results of demographic variables. The natural log of average household size in each municipality, $\ln Family$, is significant and negative, which is caused by collective consumption. For

[4] We carfully chose panel model among the three models, pooled OLS, FEM, and REM. We employ systematic model selection. Employed Test statistics are the F test, Breusch-Pagan Lagrange Multiplier test (BP test), and Hausman test (See Hsiao, 2002). The test strategies are listed below: 1) To choose between the pooling OLS and FEM, we apply the F test. 2) To choose between the pooled OLS and REM, we apply the BP test. 3) To choose between the FEM and REM, we apply the Hausman test. Finally, FEM was selected.

example, there will be only one newspaper per household, and so household waste per capita will decrease as household size increases. This result is similar to the result that presented by Callan and Thomas (2006).

The values of the natural log of population density (population per square mile), $\ln$ *Popd*, controls for land scarcity. However, the estimated coefficient is not statistically significant.

The per capita income, $\ln Income$, is a variable for the natural log of the average per capita income of a municipality. The coefficient is statistically significant at conventinal level of significance and negative in total waste. This is thought to be because the variable is affected by many channels, such as the amount of consumption (positive effect) and environmental consciousness (negative effect). Due to these combined channels, the coefficient is negative relation with waste generation.

The ratio of population variales of over 65 ages, *Over 65*, is significant, and negative. This results from the fact that retired people appear to have considerable time and can therefore refuse containers and packaging waste, or composting on the backyard.

4 Conclusion

In this paper, we use a balanced panel of 2951 municipalities in Japan on solid waste covering the 1998-2002 period to empirically examine whether UBP policy increases illegal dumping. We assume the exogeneity of neighboring municipalities' pricing decision, and use the model that considers the exageneity of illegal dumping due to the introducing UBP. Moreover, the use of panel data enables us to take the endogeneity concerning municipality's pricing policy into consideration. The major findings of the present study is that there is illegal dipsosal relative to the fixed pricing and two-tier pricing.

Future studies may wish to consider the endogeneity problem concerning neighboring municipalities' determining prices. Particularly, if they introduce UBP, it could cause biases in estimation. In order to overcome this problem, we have to estimate simultaneously both the spatial lag of X (SLX) model whose dependent variable is the amount of total waste and the spatial lag dependence model whose dependent variable is the prices.

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Table 1: Pooled sample descriptive statistics (2951 municipalities, 5 year period)

Variable	Mean	SD	Min	Max	definition
$\ln collectper$	-1.41	0.42	-4.23	0.65	Natural log of total waste generation (per capita year, ton)
D_{ubp}	0.29	0.45	0	1	Dummy variable of unit-based pricing
D_{fix}	0.16	0.37	0	1	Dummy variable of fixed pricing
D_{fem}	0.03	0.18	0	1	Dummy variable of two-tier pricing
$\ln Family$	1.11	0.15	0.49	1.55	Natural log of average household size
$\ln Popd$	5.13	1.51	0.26	8.73	Natural log of population density
$\ln Income$	0.10	0.25	-0.91	2.27	Natural log of per capita income (million yen)
Over 65	0.24	0.07	0.08	0.51	Population rate of age 65

Table 2: Estimation result

VARIABLES	(1) Non-SLX model	(2) SLX model
D_{ubp}	-0.0223**	-0.0226**
	(0.00884)	(0.00954)
D_{fix}	-0.0144	-0.0202**
	(0.00933)	(0.0102)
D_{fem}	0.0212**	0.0114
	(0.00946)	(0.00953)
$W \times D_{ubp}$		-0.00167
		(0.00296)
$W \times D_{fix}$		0.00573*
		(0.00332)
$W \times D_{fem}$		0.0123***
		(0.00435)
$\ln Family$	-0.418**	-0.413**
	(0.178)	(0.178)
$\ln Popd$	-0.0906	-0.0907
	(0.0870)	(0.0869)
$\ln Income$	-0.0879*	-0.0882*
	(0.0505)	(0.0504)
Over 65	-1.006*	-0.951*
	(0.539)	(0.537)
Year 98 (benchmark)	–	–
Year 99	0.0305***	0.0304***
	(0.00511)	(0.00512)
Year 00	0.0653***	0.0656***
	(0.00922)	(0.00924)
Year 01	0.0717***	0.0718***
	(0.0133)	(0.0133)
Year 02	0.0872***	0.0865***
	(0.0172)	(0.0172)
Constant	-0.163	-0.184
	(0.465)	(0.464)
Observations	14,755	14,755
R squared	0.069	0.071
Number of code	2,951	2,951

Robust standard errors in parentheses

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