DETERMINING FACTORS OF WASTE MANAGEMENT IN JAPAN

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Abstract
The volume of waste produced is a major concern for Japan and has heightened the interest in waste management and recycling. This paper examines the factors that impact the municipal solid waste per capita and the recycle rate, applying panel data from 2001 to 2014 for each prefecture in Japan. The results first find that regions with a higher share of female population have a lower municipal solid waste per capita and a higher recycle rate, both at significant levels. The second finding is that a higher share of senior citizens population also has a significantly lower municipal solid waste per capita. On the other hand, the results show that higher gross domestic product and higher rate of educational attainment results in greater municipal solid waste per capita and lower recycle rate at a significant level. Results indicated that regions with robust financial indicators have significantly higher recycle rates.
Keywords: municipal solid waste per capita, recycle rate, gross domestic product per capita, financial strength, demographic variables.

1. INTRODUCTION

With the development of economic activities and increase in consumption, there is growing social concern over the increased production of waste and heightened interest in recycling. This social concern and interest also apply to Japan (Ministry of the Environment, 2016). This paper will examine the factors that impact the behaviours concerning waste and recycling. There is extensive research on waste management challenges and the determinants. These determinants cover economic factors, policy and systems related factors, and social factors. Concerning the economic factors, Beede and Bloom (1995) examine independent variables such as per capita income and population across countries including developed and developing countries to understand their impact on municipal solid waste. Saltzman, Duggal and Williams (1993) study the impact changes to the household's income has on its recycling effort and Wertz (1976) examines the impact on the production of waste. Berger (1997) studies socioeconomic and demographic variables including income to examine their relationship with recycling and environmental behaviour. Concerning policy and systems related factors, Jenkins (1993) reviews the introduction of household user fees for solid waste service in nine US communities and their impact on solid waste reduction. Atri and Shellberg (1995) analyse a possible system of Pigovian taxes and refunds reflecting disposal and recycling costs to improve the efficiency of waste management. Dobbs, (1991) considers both private and social costs for waste collection and reviews a user charge for collection and a refund or user subsidy associated with proper waste disposal. As for social factors, Swami et al. (2011) examine age as an independent variable and its impact on waste management in the United Kingdom. Ekere, Mugisha and Drake (2009) examine a wide range of social factors such as gender, peer influence, land size, location of household and membership of environmental organization for a region in Uganda to observe their impact on separate collection of waste. Lee, Kurisu and Hanaki (2013) analyse the influential factors of socio-demographics on pro-environmental behaviours such as the reduction of waste, conservation and recycling in Tokyo and Seoul. Saphores, Nixon and Ogunsetian (2006) cover unique socio-demographic variables such as education, environmental beliefs, and political affiliation to examine the key factors that influence the willingness to recycle electronic waste in California. Nixon and Saphores (2009) conduct a study of the United States concerning how different sources of information such as print media, television, radio and face-to-face communication influence the decision to start recycling. Other studies on demographic and socio-economic factors on recycling behaviours include Li (2003), Ando and Gosselin (2005), Barr et al. (2005), Oates and McDonald (2006), Barr (2007) and Babaei et al. (2015).

Previous studies on waste management in Japan are limited. Kurisu and Bortoleto (2011) studied megacity regions of Tokyo, Osaka and Aichi concerning age, gender and the charging of plastic shopping bags in order to analyse their relationship with waste prevention behaviours. The effect of waste disposal charges to control waste and encourage recycling for Japan is examined by Usui (2003). Sasao (2000) examines the impact user fees for municipal solid waste services would have on solid waste reduction in agricultural cities, industrial cities and commercial cities. The impact socio-demographic factors have on recycling are examined by Yoshida (2009) for Kyoto, Osaka, Hyogo, Nara and Shiga. Nakamura, Kawase and Miyashita (2007) study the impact male population has on municipal solid waste per capita and Shinoki (2017) studies the impact senior citizens have on waste reduction in Sendai, Japan. Maruo, Nishigaya and Ochiai (1997) study the size of households and their impact on municipal solid waste per capita.

This paper intends to study the following areas which have not been adequality covered in past research on waste management in Japan. First, using recent Japan prefecture level panel data, it will apply the municipal governments' financial indicator. Since the collection of waste and recycling is led by the municipal government, its financial situation is likely to have an impact on waste management. Secondly, the gross domestic product (GDP) per capita, which is a factor related to production and consumption that causes waste will be adopted, using recent panel data covering all the prefectures in

Japan. This is to examine its relationship with the municipal solid waste per capita and with the recycle rate. As identified in past studies on the Environmental Kuznets Curve, the increase in production and consumption can increase the volume of waste and the increase in wealth could also be invested in the development of technology and influence the preference concerning the environment and health-consciousness (Grossman, 1995; Grossman and Krueger, 1995). The level of educational attainment may also be an influencing factor. Higher education may increase job opportunities, providing higher income, which may trigger greater consumption and as a result produce more waste. Higher education and the increased income may also influence the preference and behaviour towards the environment and health resulting in a reduction of waste and an increase in recycle rate. This paper will further examine multiple demographic variables that include recent panel data of all the prefectures in Japan. First, the impact gender differences have on waste and recycling will be reviewed along with the share of senior citizens to examine the impact of age. With the challenges Japan faces with the rapidly aging population, any insight to support initiatives for the aging society will be beneficial. Educational attainment will also be reviewed for the reasons explained above.

By covering these areas, this paper aims to fill the gap of previous studies. The municipal solid waste per capita and the recycle rate will be covered as dependent variables and the panel data for the 47 prefectures in Japan from 2001 to 2014 will be adopted in the analysis.

2. DATA AND METHODS

This section will provide explanation on the data and methods adopted. The data sources are provided in the Appendix.

Waste and Recycling

The data adopted for waste is the municipal solid waste per capita (MSW). This is based on the 'municipal solid waste' defined in Article 2 of Clause 5 of the Waste Management and Public Cleansing Act, 'The basic policy concerning the strategy and comprehensive planning of the reduction and appropriate treatment of municipal solid waste'. Total municipal solid waste is the sum of the volume of collected solid waste; the volume of delivered solid waste by the producer; and the volume of recyclable resources collected by community groups. This is then divided by the total population to obtain the MSW. The recycle rate (REC) is the sum of the volume of municipal solid waste directly recycled; the volume of recyclable resources obtained from the intermediate treatment of municipal solid waste; and the volume of recyclable resources collected by community groups, divided by the sum of the volume of total treated municipal solid waste and the volume of recyclable resources collected by community groups, multiplied by 100. The data adopted concerning waste and recycling is from the Nation Survey on the State of Discharge and Treatment of Municipal Solid Waste.

Financial Strength

The financial strength of the local government is a factor that has the potential to impact the production of waste and recycling. If the financial situation of the municipal government is strong, a well-developed waste management system such as increased collection of separate waste would be possible. However, improved convenience of waste disposal by households and businesses could lead to an increase in waste. Regions with strong financial indicators may be able to increase the type of separate waste collection, resulting with an increased burden to households and businesses which may encourage them to reduce the waste produced. Considering these various responses, the coefficient for the financial indicator could be either positive or negative. The local government play an important role in the recycling rate, since performance is influenced by the recycling facilities and management systems available. Increasing the recycle rate will likely mean an increased cost to outsource the work or subsidies for the development and maintenance of the facilities which will require a financially robust municipal government. Hence, a strong financial indicator could improve the REC, resulting in a positive coefficient.

As for the municipal government financial indicator index, this paper adopts the financial capability indicator (Fin) obtained by dividing the basic financial revenue with the basic financial needs. In order to minimize the impact for annual differences, it applies the average for the last 3 years. Higher Fin indicates a stronger financial condition. Since waste management is conducted mainly by the municipalities, the weighted average value is obtained by weighing the Fin for each city/town/village for all prefectures with the corresponding expenditure. Since recycling efforts are also led by the municipalities, it applies the same indicator.

Real Gross Domestic Product

An increase in GDP per capita will increase consumption and as a result increase the volume of waste produced. The increase in GDP per capita could also stimulate the investment and development of technology for waste management as well as influence the behaviour concerning health and the environment. This effect is widely studied in empirical research of the Environmental Kuznets Curve. If the effect from the former with the increase in consumption is greater than the latter effect, then a growth in GDP per capita would result in an increase in MSW and a decrease in REC, and the coefficient will show a positive sign for MSW and a negative for REC. However, if the latter effect is stronger, then a reduction in MSW and increase in REC can be expected. In this way, the coefficients for the GDP per capita may have both signs. The analysis will adopt the real gross domestic product per capita for each prefecture of Japan, referred to as the real gross prefecture product per capita (GPP).

Education

It has been identified that demographic variables affect human behaviours such as consumption (Kotler and Keller, 2010). This paper adopts demographic variables in order to examine the human behaviour concerning the production of waste and recycling. The first demographic variable applied is the attainment of education. A higher level of education could lead to a higher household income, triggering an increase in consumption and resulting with an increase in waste. Regions with higher level of educational attainment are able to retain these high qualified residents in their region[1], which attracts businesses looking for high qualified workers and as a result the production and consumption increases. Higher educational attainment could also impact the preference and behaviour towards the environment and health, resulting with an effort to reduce waste and increase recycling. If the effect from the increase in consumption outweighs the effect from the behavioural changes, then a positive sign could be expected for MSW and a negative sign for REC. However, if the effect of the latter is stronger, then the same sign may not be achieved. The indicator for educational attainment rate (Ed) adopts the high school enrolment rate.

Gender

The second demographical variable focuses on gender, since the inherent or acquired influence from gender often impacts behavioural preference and research on the impact from gender differences are extensive (e.g. Kurisu and Bortoleto, 2011; Rendon, 2013). Hence, the share of female population (Fem) is examined to understand the impact gender may have on waste and recycling. Fem is obtained by dividing the female population with the total population.

Age

The third demographic variable examined is the share of senior citizen population (Snr). With its rapidly aging population, it is important for Japan to consider initiatives that address the challenges faced by the aging society. Hence, observations will be made to determine whether regions with a higher share of elderly population have an impact on waste and recycling. The analysis may provide insight on

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[1] Analysis has been conducted on the relationship between educational attainment and the rate of population outflow where the results were significant and negative. Details can be provided upon request.

whether demographic factors have an impact on the preference and behaviour concerning waste management and the scale of consumption. The Snr is obtained by dividing the population of 65 years of age and older with the total population.

As explained above, the variables representing the financial strength, real GDP and demographic variables such as education, gender and age have the potential to impact MSW and REC. These variables are examined in a panel data which covers the 47 prefectures in Japan for the period of 2001 to 2014. Therefore, the basic model concerning the determining factors of MSW and the REC is as follows.

With respect to the model for MSW,

$$MSW_{it} = GPP_{it} + Ed_{it} + Fin_{it} + Fem_{it} + Snr_{it} + D_t + \delta_i + e_{it}. \quad (1)$$

As for the REC model,

$$REC_{it} = GPP_{it} + Ed_{it} + Fin_{it} + Fem_{it} + Snr_{it} + D_t + \delta_i + e_{it}. \quad (2)$$

Here, i is region, and t is fiscal year. D_t denotes year dummy, δ_i represents individual effects of the region in order to control the effects from unobservable regional specific factors and behaviours. e_{it} is error term, which is the combined time series and cross-sectional error components.

When putting emphasis on the benefit of being able to observe the relationship between the dependent variables and the explanatory variables by controlling the individual effects of each region which are unobservable and unchangeable across time and allows the existence of correlation between explanatory variables and individual effects, the fixed effects model is effective. Therefore, we employ the fixed effects model when its advantage over the pooled ordinary least squared model and random effects model is confirmed by conducting the F test which examines the null hypothesis that all individual effects are zero and the Hausman test which analyses the null hypothesis that explanatory variables are indifferent from the error term which represents individual effects. We treat dependent variables and explanatory variables as natural logarithms and include year dummy in order to control the individual effects specific to a particular year but applies to all the regions such as informal and formal regulations. Here, we will explain the models based on equation (1) and (2). Since we can predict the correlation between GPP and Ed to be positive, this would mean regions with higher level of education can expect households with higher income, which could encourage consumption and supply, resulting in an increase in GPP. Regions with higher GPP could also expect greater tax revenue, enabling the region with a stable financial condition. Furthermore, regions with high Ed that results in higher income can expect higher tax revenue and stable financial conditions. Therefore, there is the possibility of multicollinearity if these three variables are employed at the same time. Concerning the models on MSW based on equation (1), Model (1) of Table 1 represents when there is correlation between GPP and Fin and between GPP and Ed. In order to avoid multicollinearity, it removes Fin and Ed from equation (1). Model 2 represents correlation between Fin and GPP and between Fin and Ed, so GPP and Ed have been excluded from equation (1). Model 3 follows the same procedure based on correlation between Ed and GPP and between Ed and Fin, removing GPP and Fin. Models (4)-(6) represent only one correlation between the variables, so if there is a correlation between GPP and Ed in Model (4), then Ed is removed from equation (1). Following the same procedure, Model (5) removes Fin and Model (6) removes GPP from equation (1). Model 7 represents when there are no correlations between the variables, so all three variables are employed.

This analysis is replicated for REC in Table 2 in the same order based on equation (2), with Model (1) in Table 1, corresponding to Model (8) in Table 2 and Model (7) in Table 1 corresponding to Model (14) in Table 2.

3. RESULTS

TABLE 1. DETERMINANTS FOR TOTAL MUNICIPAL SOLID WASTE PER CAPITA

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GPP	0.202*** (0.0608)			0.200*** (0.0612)	0.185*** (0.0625)		0.185*** (0.0627)
Fin		0.00342 (0.00606)		0.00125 (0.00605)		0.00222 (0.00608)	0.000662 (0.00607)
Ed			0.128** (0.0547)		0.0717 (0.0642)	0.113* (0.0633)	0.0711 (0.0645)
Fem	-6.668*** (1.041)	-6.858*** (1.057)	-7.611*** (0.922)	-6.639*** (1.051)	-7.002*** (1.083)	-7.380*** (1.095)	-6.984*** (1.096)
Snr	-0.122* (0.0694)	-0.108 (0.0722)	-0.136** (0.0617)	-0.118 (0.0717)	-0.127* (0.0695)	-0.120* (0.0724)	-0.125* (0.0720)
Constant	-5.866*** (0.648)	-5.670*** (0.675)	-6.735*** (0.664)	-5.830*** (0.671)	-6.351*** (0.780)	-6.481*** (0.812)	-6.328*** (0.809)
Year dummy	YES	YES	YES	YES	YES	YES	YES
F test	34.08 (0.0000)	29.4 (0.0000)	39.14 (0.0000)	29.38 (0.0000)	34.12 (0.0000)	29.32 (0.0000)	28.8 (0.0000)
Hausman test	61.96 (0.0000)	88.09 (0.0000)	87.16 (0.0000)	153.52 (0.0000)	60.6 (0.0000)	23.44 (0.1355)	11 (0.8943)
Observations	658	658	752	658	658	658	658
R-squared	0.632	0.625	0.627	0.632	0.633	0.627	0.633

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

We will first review the results concerning the MSW. From Table 1, we can observe that the fixed effects models are preferred over the random effects models and the pooled ordinary least square models in all the models examined, excluding Models (6) and (7), based on the Hausman test and F test. Taking the results of these tests and the limitation of space into consideration, we will only describe the results of the fixed effects models. According to the fixed effects models, it shows that the region with a higher Fem, emits less waste at a significant level. These results are consistent with the findings by Nakamura, Kawase and Miyashita (2007)'s study on the municipal solid waste in Japan. This could be interpreted as women being more concerned about the environment and health related to waste than men or women may be consuming less resulting in producing less waste. The results of the other demographic variable, Snr share similar results, with the region with a higher Snr significantly produces less waste in three of the five models (Models (1), (3) and (5)). These results are consistent with the results by Shinoki (2017), which find that senior citizens contribute to waste reduction in Sendai, Japan.

TABLE 2 - DETERMINANTS OF RECYCLE RATE

Model	(8)	(9)	(10)	(11)	(12)	(13)	(14)
GPP	-0.312** (0.147)			-0.372** (0.147)	-0.287* (0.151)		-0.337** (0.150)
Fin		0.0499*** (0.0145)		0.0539*** (0.0145)		0.0524*** (0.0145)	0.0552*** (0.0145)
Ed			-0.235* (0.138)		-0.110 (0.156)	-0.239 (0.151)	-0.162 (0.154)
Fem	7.276*** (2.522)	8.915*** (2.523)	8.928*** (2.330)	8.508*** (2.517)	7.791*** (2.625)	10.02*** (2.615)	9.295*** (2.626)
Snr	-0.127 (0.168)	0.0146 (0.172)	-0.117 (0.156)	0.0326 (0.172)	-0.120 (0.168)	0.0392 (0.173)	0.0476 (0.172)
Constant	8.006*** (1.570)	9.246*** (1.611)	9.604*** (1.678)	9.544*** (1.608)	8.753*** (1.891)	10.96*** (1.940)	10.68*** (1.938)
Year dummy	YES	YES	YES	YES	YES	YES	YES
F test	46.73 (0.0000)	46.99 (0.0000)	44.63 (0.0000)	47.56 (0.0000)	46.59 (0.0000)	46.79 (0.0000)	47.16 (0.0000)
Hausman test	29.52 (0.0207)	28.18 (0.0301)	32.9 (0.0171)	33.02 (0.0112)	29.61 (0.0293)	31.02 (0.0199)	34.36 (0.0114)
Observations	658	658	752	658	658	658	658
R-squared	0.459	0.466	0.504	0.472	0.460	0.468	0.473

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

This suggests that senior citizens are also either more conscious of the environment and health or consume less resulting in less waste. Next, with regards to GPP, the results are positive and significant in all the models. These results are in line with the studies by Beede and Bloom (1995) and the studies on Japan by Sasao, (2000), Usui (2003) and Nakamura, Kawase and Miyashita (2007). This indicates that the increase in GPP is an increase in MSW, which means that the effects from the increase in production and consumption which increases waste, is more dominant than any waste reducing effect such as the advancement in waste management technology or changes in preference and behaviour concerning the environment and health. The Ed results from Model (3), is positive and significant. This suggests that the region with higher educational attainment may have higher household income which encourages consumption and increase waste. Any effects that impact the reduction of waste, such as education to increase awareness of the environment does not seem to be strong enough.

Next, the results for the models concerning the REC are provided. From the observations of Table 2, we can observe that the fixed effects models are preferred over the random effects models and the pooled ordinary least square models in all the models examined, based on the Hausman test and F test. Hence, the results of the fixed effects model are observed. The results in Table 2 suggest that regarding Fem, the REC are significantly higher in regions with higher Fem in all the models (Models (8) through (14)). This could be due to the lower consumption by women, resulting in less waste which is included in the denominator of the recycle rate or it may be due to women preferring to recycle due to the impact on the environment. These results are consistent with the studies by Li (2003), Ando and Gosselin (2005), Barr et al. (2005), Oates and McDonald (2006), Saphores, Nixon and Ogunsetian (2006), Barr (2007), Swami et al. (2011) and Babaei et al. (2015) which suggest that women are more likely to recycle. Results by Lee, Kurisu and Hanaki (2013) also support that women have a higher rate of pro-environmental behaviours, such as recycling in Seoul and Tokyo. It is also consistent with the results on Japan by Yoshida (2009).

On the other hand, the recycle results for the Snr show signs that are inconsistent and insignificant. The results for Japan by Yoshida (2009) and Shinoki (2017) identified positive impacts on recycling efforts by the senior population. We can observe in all the models, that GPP shows negative signs at a significant level, meaning that the greater the GPP is, the lower the REC. This suggests that the effect from the increase in production and consumption from the GPP growth is much stronger than any effect that encourages recycling. The result for Ed in Model (10) shows a significantly lower REC in the regions with higher Ed.

Since we learned from the results of MSW, that higher Ed leads to higher MSW, which is included in the denominator of the REC may be causing the lower REC. With regards to the Fin, which represents the stability of the financial conditions, in all the models, the results are positive and significant, suggesting that the greater the Fin is, the REC is higher. This may suggest, as described above, that robust financial conditions better equip the region to develop and maintain recycling facilities and outsource recycling.

We have treated the explanatory variables of GPP, Ed and Fin as exogenous variables. However, these variables have the possibility of endogeneity for the following reasons. First of all, in the case of MSW, if we examine GPP, as MSW increases, the cost of waste management increases which may increase tax, resulting in increased financial burden for household and businesses. This in turn, could restrict consumption, resulting in a decrease in production, reducing the GPP. This suggests the possibility of simultaneity between GPP and MSW. Hence, the estimates of explanatory variables may be inconsistent due to endogeneity. This will also occur in the case of Fin. That is, with the increase in MSW, the financial burden may increase, creating the possibility of simultaneity between Fin and the MSW. The same can occur in the case of Ed, since an increase in MSW, may increase the tax burden, resulting in less household funds to cover educational cost, causing a reduction in Ed. Therefore, it is also predicted that there is the possibility of simultaneity between the Ed and MSW. Accordingly, the endogeneity will also occur in this case, suggesting that the estimate of the Ed will be inconsistent. Similar consideration is required for the REC. Low REC means that there will be the possibility of greater amount of waste to be treated. As a result, the financial burden will become larger, which could lead to increased tax burden for households and businesses. Hence, consumption may be reduced and GPP may decrease. High REC may also cause an increase in expenditure for the local government to support the recycling efforts such as outsourcing expenditures, resulting in a weaker Fin. Therefore, there is the possibility of simultaneity between Fin and REC. For Ed, the explanation that was provided for the MSW would apply to REC. Accordingly, there is the possibility of endogeneity between the explanatory variables, of GPP, Fin and Ed, and the dependent variables, of MSW and REC. Hence, this is taken into consideration in the following models.

First, concerning the analysis on MSW in Table 3, possibility of endogeneity with GPP, Fin and Ed are taken into consideration and applied to Models (1) - (7) of Table 1, which cover the various correlations between the explanatory variables. These results are Models (15) - (21) in Table 3 and are represented in the same order, with Models (1) in Table 1 corresponding to Model (15) in Table 3.

The same analysis is applied to REC in Table 4 in the same order as Table 3. For example, Model (22) in Table 4 corresponds to Model (15) in Table 3 and Model (28) in Table 4 corresponds to Model (21) in Table 3. In order to take endogeneity into consideration, the one year lagged values are applied as the explanatory variables (lagGPP, lagFin, lagED). From the results of the F test and Hausman test, the fixed effects model was preferred over the random effects models and the pooled ordinary least square models in all the models examined, hence the results of the fixed effects models are provided in Table 3 and 4.

TABLE 3 - DETERMINANTS FOR TOTAL MUNICIPAL SOLID WASTE PER CAPITA - ENDOGENEITY CASE

Model	(15)	(16)	(17)	(18)	(19)	(20)	(21)
lagGPP	0.184*** (0.0586)			0.189*** (0.0589)	0.174*** (0.0602)		0.178*** (0.0605)
lagFin		-0.00216 (0.00582)		-0.00416 (0.00581)		-0.00302 (0.00584)	-0.00453 (0.00583)
lagEd			0.142** (0.0560)		0.0469 (0.0606)	0.0902 (0.0597)	0.0505 (0.0608)
Fem	-6.517*** (0.948)	-6.953*** (0.960)	-7.498*** (0.946)	-6.613*** (0.958)	-6.694*** (0.976)	-7.273*** (0.982)	-6.812*** (0.988)
Snr	-0.144** (0.0702)	-0.139* (0.0728)	-0.135** (0.0660)	-0.157** (0.0725)	-0.147** (0.0704)	-0.149** (0.0730)	-0.161** (0.0727)
Constant	-5.777*** (0.583)	-5.822*** (0.611)	-6.716*** (0.679)	-5.897*** (0.607)	-6.067*** (0.693)	-6.406*** (0.722)	-6.219*** (0.720)
Year dummy	YES	YES	YES	YES	YES	YES	YES
F test	35.4 (0.0000)	31.06 (0.0000)	38.23 (0.0000)	31.06 (0.0000)	35.39 (0.0000)	30.81 (0.0000)	30.26 (0.0000)
Hausman test	75.52 (0.0000)	144.9 (0.0000)	82.11 (0.0000)	26.34 (0.0684)	72.21 (0.0000)	58.68 (0.0000)	60.05 (0.0000)
Observations	658	658	705	658	658	658	658
R-squared	0.655	0.649	0.638	0.655	0.655	0.650	0.655

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

TABLE 4 - DETERMINANTS OF RECYCLE RATE- ENDOGENEITY CASE

Model	(22)	(23)	(24)	(25)	(26)	(27)	(28)
lagGPP	-0.294** (0.136)			-0.334** (0.136)	-0.278** (0.140)		-0.312** (0.140)
lagFin		0.0330** (0.0134)		0.0365*** (0.0134)		0.0345** (0.0135)	0.0372*** (0.0135)
lagEd			-0.271** (0.136)		-0.0668 (0.141)	-0.166 (0.138)	-0.0961 (0.141)
Fem	7.978*** (2.208)	9.420*** (2.214)	9.518*** (2.302)	8.821*** (2.218)	8.230*** (2.273)	10.01*** (2.266)	9.200*** (2.288)
Snr	-0.106 (0.164)	-0.0258 (0.168)	-0.130 (0.160)	0.00589 (0.168)	-0.102 (0.164)	-0.00825 (0.169)	0.0140 (0.168)
Constant	8.473*** (1.359)	9.390*** (1.410)	10.12*** (1.653)	9.522*** (1.406)	8.885*** (1.615)	10.46*** (1.668)	10.13*** (1.669)
Year dummy	YES	YES	YES	YES	YES	YES	YES
F test	57.34 (0.0000)	57.05 (0.0000)	49.64 (0.0000)	57.62 (0.0000)	57.13 (0.0000)	56.75 (0.0000)	57.08 (0.0000)
Hausman test	34.29 (0.0000)	32.36 (0.0090)	34.61 (0.0070)	36.9 (0.0035)	33.66 (0.0093)	43.55 (0.0004)	35.09 (0.0092)
Observations	658	658	705	658	658	658	658
R-squared	0.366	0.368	0.445	0.374	0.367	0.369	0.375

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Theoretical and Empirical Researches in Urban Management
Volume 14 Issue 3 / August 2019

Concerning the case of MSW, from Table 3, the estimated coefficient results for Fem are found to be negative and significant for all the models. These results support the results in Table 1, where the three explanatory variables, GPP, Fin and Ed are treated as exogenous variables. This means that even when these three variables are treated as endogenous variables, the greater the Fem is, the lesser the MSW. Also, concerning the other demographic variable, the Snr, the results in Table 3, are negative and significant in all the models, which is consistent to the Fem results. These results also support the results in Table 1, where the three explanatory variables, GPP, Fin and Ed, are treated as exogenous variables. Furthermore, concerning lagGPP, from Table 3, results from all the models show a positive and significant sign, supporting the results of Table 1. This suggests that the greater the lagGPP is, the greater the MSW. The lagEd also shows a positive and significant sign in Model (17), which supports the results of Model (3) where the variables are treated as exogenous variables. On the other hand, lagFin show negative signs, which are inconsistent with the results of the case where the index is treated as an endogenous variable. However, both results are statistically insignificant.

Next, in the case of REC, from Table 4, lagGPP shows a negative and significant sign in all the models, supporting the results of Table 2 where the GPP is treated as an exogenous variable. This means that in either cases, where the GPP is an endogenous variable or an exogenous variable, the greater the GPP is, the lesser the REC. The lagEd also shows a negative and significant coefficient for Model (24) as seen in Table 4. This supports the result in Model (10) of Table 2 where the Ed is treated as an exogenous variable. Moreover, lagFin shows a positive and significant sign in all the models in Table 4, which supports the result of Table 2 where the Fin is treated as an exogenous variable. This suggests that the more stable the financial conditions are in the regions, the REC are significantly higher. This suggests that adequate funds are necessary to develop and maintain recycling efforts. Concerning the demographic variable, Fem, the results are positive and significant in all the models. These results are consistent with the results in Table 2 for the Fem explanatory variable, suggesting that the region with higher Fem, has a higher REC. Concerning the other demographic variable, Snr, the results are inconsistent and all the results are not at a statistically significant level.

Since we employ dependent variables and explanatory variables in the form of natural logarithms, the coefficients of explanatory variables represent the elasticities. Therefore, we can compare the coefficients amongst the explanatory variables. The fixed models which were preferred in the results of the F test and Hausman test were examined for independent variables with statistically significant results. Hence, if we focus on the magnitude of the coefficients with significant results, in the case of MSW, the elasticity in all the models of Fem are the highest, ranging from -6.517 to -7.611. GPP is the second highest for all models, ranging from 0.174 to 0.202, followed by Snr, ranging from -0.122 to -

0.161 and Ed ranging from 0.128 to 0.142. Concerning the REC, the Fem elasticity is between 7.276 to 10.02 and is the highest amongst the coefficients in all the models as in the case of MSW. GPP again is the second highest ranging from -0.278 to -0.372, followed by Ed ranging from -0.235 to -0.271 and then Fin ranging from 0.0330 to 0.0552.

4. CONCLUSIONS

With the growth in economic activities from the increase in production and consumption, the increase in municipal solid waste is becoming a challenge. Thus, social awareness towards waste management and recycling in Japan has been growing. This article, therefore, examines the determining factors of municipal solid waste per capita and the recycle rate, making use of panel data for each region in Japan between 2001 and 2014.

The main results for the demographic variable, the share of female population, show negative and significant coefficients estimated in all the models concerning municipal solid waste per capita, but positive and significant in all the models of the recycle rate. The opposite results were found for higher educational attainment with results that are positive for all the models and some at a significant level for municipal solid waste per capita and negative and significant for recycling in some of the models. Senior citizens were found to produce significantly less waste. These results suggest that existing efforts to reduce municipal solid waste and to increase the recycle rate is effective with some demographics but not others. A different approach may be necessary to encourage waste reduction such as a stronger reinforcement of social systems towards the adoption of 'refuse', 'reduce' and 'reuse'. Reviewing the content of education may also be required, since what is being covered even in higher education on environmental consideration and waste management does not seem to be effective against the impact that higher education may have on increasing household income and consumption. For recycling, an incentive may be necessary such as a reward scheme or a deposit/refund scheme. In this way, one size does not seem to fit all concerning improvements to waste reduction and recycling and a wider range of approaches may need to be applied to get a larger range of participation.

Gross domestic product per capita for each prefecture also confirmed positive and significant results in all the models. Unfortunately, during the time period observed, any effects to improve technology or to change human behaviour to support the environment and health from the increase in income has not resulted in waste reduction. A solution may be to utilize the increased tax revenue gained from the increase in production to support waste management technology and recycling development.

Finally, concerning the impact of the financial conditions of the regions, the results show that higher financial index leads to higher recycle rate in all the models. This suggests that improvements to

Theoretical and Empirical Researches in Urban Management
Volume 14 Issue 3 / August 2019

stabilize financial conditions are needed to improve the recycle rate. Currently, improving the recycle rate may be too costly for some regions, so it may also be necessary to seek innovative cheaper solutions, or it may require initiatives and support at a national level.

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APPENDIX

Variable	Sources
Municipal Solid Waste per capita (MSW)	*MSW*: Nation Survey on the State of Discharge and Treatment of Municipal Solid Waste, Ministry of the Environment Population: Population Estimates, Ministry of Internal Affairs and Communications
Recycle Rate (REC)	Nation Survey on the State of Discharge and Treatment of Municipal Solid Waste, Ministry of the Environment
Financial Capability Indicator (Fin)	Survey of public facilities, Ministry of Internal Affairs and Communications
Real Gross Prefectural Product per capita (GPP)	*GPP*: Prefectural Accounts, Cabinet Office Population: Population Census, Population Estimates, Ministry of Internal Affairs and Communications
Educational Attainment Rate (Ed)	School Basic Survey, Ministry of Education, Culture, Sports, Science and Technology
Share of Female Population (Fem)	Population Census, Population Estimates, Ministry of Internal Affairs and Communications
Share of Snior Citizen Population (Snr)	Population Census, Population Estimates, Ministry of Internal Affairs and Communications

Theoretical and Empirical Researches in Urban Management
Volume 14 Issue 3 / August 2019