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Reexamining the waste-income relationship*

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Abstract

Even though many studies on Environmental Kuznets curve (EKC), are following a seminal work by Grossman and Krueger(1991), limited studies are available for municipal solid waste's cases (WKC). Mazzanti and Montini eds. (2009) is a first comprehensive study of WKC with European data. More importantly, they define a absolute decoupling as 'descending side of an inverted U shape' and relative decoupling as 'ascending path of an inverted U shape. In this paper, we add a new evidence for WKC by using municipal solid waste's data in Japan. The successful result was derived due to highly disaggregated data as was suggested by Mazzanti and Zoboli (2009) as well as the richness of data set.

1 Introdcution

Environmental Kuznets curve (hereafter EKC) hypothesis has been controversial even though huge amounts of research were published after the seminal work by Grossman and Krueger (1991). Early Discussion was well summarized by Stern(2004) or Dinda (2003) where opponents and proponents of EKC hypothesis were introduced from both theoretical (e.g. Selden and Song (1995), Stokey(1998)), and empirical (e.g. Stern(1998), de Bryuyn(1997)) stand points.

After these earlier works discussed in the reviews, theoretical works moved towards more simple models. Andreoni and Levenson (2001)[1] provided a highly sophisticated theoretical

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[1]We include Andreoni and Levenson (2001) in the category of "after the earlier review' since the reviews never mentioned to it although Andreoni and Levenson (2001) was published and actually cited by the reviews.

grounds for the existence of the EKC in a highly simple static model. Before Andreoni and Levenson (2001)'s model (hereafter AL model), most theoretical models were the dynamic ones. AL model just showed that EKC does not depend on economic growth or any kind of market failures. It only depends upon the increasing returns in the abatement technology. Since AL model was simple enough to attract other authers, several papers were published in line with AL model. For example, Plassmann and Khanna (2007) tried to further generalize AL model while Johansson and Kristrom (2007) analyzed from different point of view by using familiar decomposition to the substitution and income effects and concluded in a different way. Following these prominent papers, Egli and Steger (2007) finally put earlier research line of the dynamic of growth and AL model together by developing the dynamic version of AL model.

For the empirical works regarding EKC hypothesis, as we told earlier, massive amounts of research are available and their results are mixed. According to Chimeli (2007), many panel data studies cast doubt on the EKC while long time-series data within one country usually tends to support the EKC hypothesis. Another viewpoint is the EKC evidences tend to be found in local pollution whereas many of research reject the hypothesis in the case of global pollution like CO2 emissions.

The present paper focuses on verifying whether there is an evidence of the EKC hypothesis in Japan regarding local pollutions. Since local air pollutants like SO2 were verified by Yaguchi et al.(2007), we examine the case of municipal solid waste (MSW) in Japan, which was not studied by any literature before as far as authors know. There are far less studies found in the previous literature[2] which dealt with the EKC hypothesis of MSW, known as WKC, while recent work in Mazzanti and Zoboli (2009) provided a comprehensive analysis of EU's WKC hypothesis.

[2]Kinnaman (2009) also mentions that "Although a number of economic papers have been surveyed, empirical evidence supporting the environmental Kuznets curve for solid waste generation is scarce."

Mazzanti and Zoboli (2009)'s result was not in favour of WKC hypothesis except landfill[3]. As Mazzanti and Zoboli (2009) themselves insist, there is a limit of using aggregated country data. Mazzanti and Zoboli (2009) suggest that we should use more disaggregated data within one country for the empirical work, whose kind of studies are very scarce, as is shown later in this paper, it is possible for Japan's case.

In this paper, two types of disaggregation was introduced. One is a disaggregation in a spatial sense. We try to find whether there is any relationship between MSW and income in Japan with the data of municipality level (not a country -by - country comparison). The other is that we disaggregate the type of MSW compared to previous works. Indeed, we use two types of MSW generation by separating from where it comes. One is from household and the other is from small business, convenience stores or office buildings. When we aggregate these, we have different results, which means that aggregating the type of MSW might cause some misunderstandings. Our paper proves how it happens and we believe it is an originality of our research.

The rest of this paper consists of the following. Section 2 is to explain the status quo of Japan's solid waste management and the features of its data. In Section 3, we show the results of our regression analysis with cross section data analysis. Section 4 summarizes the results and presents some policy implications.

2 Solid waste management in Japan

2.1 Japan's waste management

In this subsection, we explain some features of Japan's waste management. The waste management in Japan has been prescribed by *Waste Disposal and Public Cleansing Law*, which was originally established in 1970. Even though it was repeatedly amended, the law targets only waste management and the recycling policies are not covered by the law but there are

[3]They indeed showed a relative decoupling but not in absolute sense.

several other laws for recycling established in around 2000.

In Japan, municipal solid waste and industrial waste are rigorously separated through its whole treatment process. For example, different licenses are needed if a waste treatment firm do business with municipal solid waste (MSW) *and* industrial waste. The chapter two of the *Waste Disposal and Public Cleansing Law* defines the difference between MSW and industrial waste, and the chapter four of the law explicitly states that each municipality has a responsibility for MSW generated in its region. Therefore, waste management policies for MSW widely differ in each municipality.

For example, some municipalities collect plastics as combustible waste while other municipalities collect it as incombustible refuse, or, for recyclable waste, some municipalities pick up only packaging materials while others collect waste paper or used textile as well in addition to packaging materials. It means that a municipality can be considered as the independent decision making entity for waste management and aggregating the data, say for the national level, might hide some effects caused by different waste management policies among municipalities. Therefore, we use the data at municipality level in the empirical analysis.

/////// Table 1 around here. ///////

As for waste disposal practice, high rate of incineration and low rate of landfill are considered as the feature of Japan. Table 1 shows these points. Japan's incineration rate is about 74% while the second largest is 54% at Denmark. As for the rate of landfill, it is also very small although other countries whose national land area are very limited, e.g. Netherlands, also have very small portion of landfill out of its waste generation. Per capita waste generation in Japan is very small too but it should not be regarded that Japan generates less per-capita garbage since the definitions of MSW are not the same in each country. This is another reason that we use municipality level data within one country, not an international panel data.

3 Empirical Analysis

3.1 The model

Our objective is to test whether WKC hypothesis is valid or not in Japan. To test it, we use the following functional form

$$y_i = \alpha_i + \beta_1 x_i + \beta_2 x_i^2 + \beta_3 z_i + \epsilon_i \tag{1}$$

where y is each type of MSW, x is income and z is some related variables of prefecture i. Note that α and β are parameters. We follow this specification since Dinda (2004), a famous survey article in this field, says "[a] large number of econometric studies have used the model".If we regress something bad by per capita income and we get $\beta_1 > 0$, $\beta_2 < 0$, then the derived curve is an inverted U-shaped curve, which implys WKC is confirmed.

3.2 Data

The data of Japan's MSW is released by the Japanese Ministry of Environment (MOE). The data contains some physical features, costs and policy-related issues of solid waste in all the municipalities in Japan. The left side of Figure 1 shows the change in the total generation, recycling and landfill of MSW in Japan. It seems there is little change in terms of the total generation of MSW. There is, however, considerable fluctuation in the right hand panel of Figure 1 where the generation of MSW is disaggregated into a prefecture level and compares per capita generation in 2000 with that of 2006[4]. For example, six prefectures decrease their waste generation more than 10% within that period.

/////// Figure 1 around here. ///////

In the following empirical analysis, we use the data from Japanese Ministry of Environment and Japanese Ministry of Internal Affairs and Communications (MIAC). Japanese Ministry

[4] Note that each municipality belongs to any one of 47 prefectures in Japan.

of Environment (2008) provides waste-related data and Japanese Ministry of Internal Affairs and Communications (2008) for other socio-economic data. This means we analyze WKC with Japanese cross section data on 2005. By we select one year cross section analysis since there were many mergers of municipalities during this periods. The number of the total municipalities becomes more than half after this policy oriented merger. Table 2 shows the descriptive statistics of the variables we actually used.

/////// Table 2 around here. ///////

In Table 2, `waste` is the total MSW generation per capita (unit: ton per capita) in a municipality per year. This data can be disaggregated into two pieces, `wasteh` and `wasteb`. The former is MSW from household and the latter is the one from small business or convenience stores. Since these two MSWs generated based on different reasons. Therefore, it is desirable to separate the two when we analyze WKC hypothesis. The data collected in Japan allow us to do it. `landfill` means the per capita amount of waste finally put into landfill (unit:ton per capita). Unfortunately, since there are no available data, we cannot divide landfill waste into two types, landfill waste discharged from household and that form small business, as in the case of waste generation. In this connection, `lfsite` is the dummy variable that takes 1 if the municipality have its own landfill site. The most important non-waste variable in this paper is `income`. This is defined by total taxable gains (unit: million Yen) in a municipality. Again `perinc` (million Yen per capita) simply means per capita income and `perinc2` is square of `perinc`.

We also use other socioeconomic variables that are thought to affect the waste generation. `household` is the ratio of single-person household, and `elderly` is the ratio of elderly couple household[5]. `foreignr` indicates the ratio of residents with foreign citizenship, and `commutein` is the ratio derived from dividing the number of commuters form the areas outside the region

[5]An elderly couple household is defined as a household that is composed of the husband aged 65 years old of over and the wife aged 60years old of over.

by the number of people who commute to outside the region. Finally `popden` indicates the population density.

3.3 Summary of previous research

Recently published Mazzanti and Zoboli (2009) summarized the previous works of WKC quite comprehensively. It is shown in Table 3. According to Table 3, none of normal MSW trial succeeded, while relatively specific waste like hazardous waste, which is usually regulated severely by a central government, found the EKC evidence except Mazzanti and Zoboli (2009). As is shown later in this section, we found an evidence for MSW because of the type disaggregation.

/////// Table 3 around here. ///////

Furthermore, the present paper is different in that all the previous works depending upon the country level data. Mazzanti and Zoboli (2008) mentioned that one of the reason that WKC is not observed in his paper is that their data is too aggregated. They also suggested that future WKC or even EKC empirical works should be done with highly disaggregated data. We will show the result of the empirical work with spatially disaggregated data in the next subsection.

3.4 Evidence from the empirical work

First, we show the result of waste generation, which is rarely supported by previous empirical works. Table 4 showed the result in the case of waste generation from household and from small business.

/////// Table 4 around here. ///////

To conclude the WKC's existence, positive sign on the estimated parameter of `perinc` and negative sign on each of `perinc2` are necessary. In Table 4, for the waste generation from household, estimated parameter on `perinc2` is negative and statistically significant and the parameter on `perinc` is positive and significant too. This is the evidence of the WKC for waste generation from household in Japan. For waste from small buisness, all variables are insignificant and our type disaggregation successfully worked out. Table 4 also show the result of the landfill's case. In this result, the two coefficients on income are also significant and the signs are following the anticipation. We will interpret this result in the following section.

Table 5 includes the cases of recycling materials. Note that increase in recycling rate means less environmental burden whereas environmental burden are increased as `waste` and `landfill` increase. it simply means the sign should be opposite from the previous case to conclude the WKC in terms of recycling. In the case of recycling materials, parameters on `income` must be negative and that of `income2` be positive.

/////// Table 5 around here. ///////

Table 5 summarizes the empirical results on each recycling material. It shows that parameters on `income2` and `income` are all significant except `Plastics` but the signs on `Paper` and `Metal` are contrary to the anticipation. Another words, recycling volumes of metal and paper are decreasing as the income increases while `Glass` supports the WKC hypothesis. An interpretation of decreasing recycling materials with significance while the average recycling ratio is increasing is that the amount of recycled materials could be decreasing if the generation of wastes itself decreasing.Although our data is not rich enough to verify it, recycled materials might be substituted by reduction in the generation of MSW.

Wihin the research line of WKC, it is important to check whether the turning point of the curve is contained in the observed income level. Following the definition by Mazzanti and Montini eds. (2009), we say it is the absolute WKC if it is in the range. If not, we say it is relative WKC. As shown in Table 3, none of the previous research observed absolute WKC with household solid waste. Table 6 is the summary of our studies. These are calculated by differentiating (1) with each independent variable. For our estimates, the absolute WKC have been observed for household waste generation. The successful results are derived because of using highly disaggregated and well-arranged data.

/////// Table 6 around here. ///////

/////// Figure 2 and 3 around here. ///////

Figure 2 anf 3 are graphical illustration of turning points. Note that two vertical axes are used and its magnitude is not important for the discussion on the turning points. Since average of per capita income is 3.04 with the minimum of 2.10 and maximum of 9.46, the absolute decoupling is definitely observed.

4 Conclusion

In this paper, we showed that there is enough evidence for the existence of the WKC in Japan. The reason for this success is that we used highly disaggregated data within one country as suggested by Mazzanti and Zoboli (2009). There is another extension towards disaggregation, that is, the disaggregation in terms of material types.

Especially, it is our contribution to the existing literatures that household waste does support the WKC hypothesis while the business waste does not. In previous literatures, these two were not separated. It is obvious that the mechanism of generation of household waste and business waste is different. The business waste is, for example, likely to be affected by per capita income only in an indirect manner. To discern these two might be the key to find the WKC for MSW generation. This difference should be considered through any kind of policy discussion on waste management.

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A Figures

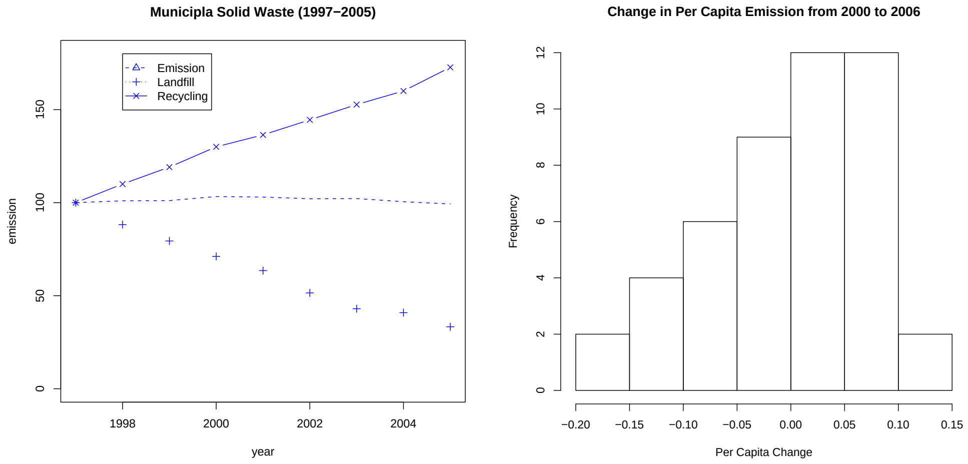

Figure 1: Fluctuation Appears When Disaggregated

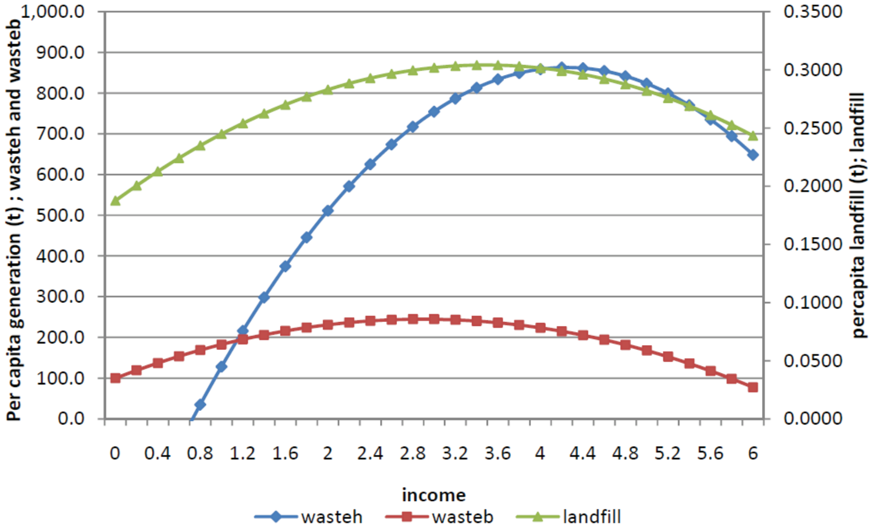

Figure 2: Turning Points of MSW and landfill

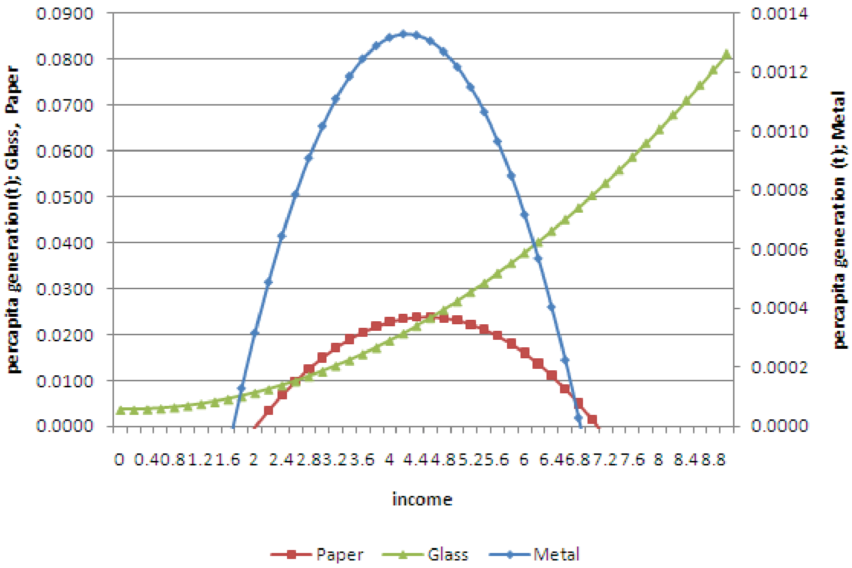

Figure 3: Turning Points of recycled material

B Tables

Table 1: Per capita generation of MSW, incineration and landfill rate in 2004

Country	MSW(kg/year)	Incineration(%)	Landfill(%)
Austria	627	22	20
Belgium	469	33	10
Denmark	696	54	4
France	567	33	38
Germany	600	24	17
Italy	538	11	57
Japan	396	78	4
Netherlands	624	34	2
Spain	662	6	55
Sweden	464	47	9
United Kingdom	600	8	69

Source: Vehlow et al.(2007) and MOE(2008)

Table 2: Summary statistics

Variable	Mean	(Std. Dev.)	Min.	Max.	N
pop	74115.6610	(264459.671)	214	8489653	1826
income	106844.1577	(498516.0703)	320	17630429	1826
perinc	3.049	(0.4968)	2.1084	9.4660	1826
waste	985.9059	(369.6995)	148.3291	6876.9805	1803
wasteh	745.9659	(280.2455)	148.3291	6414.2788	1803
wasteb	239.94	(199.7431)	0	3091.4324	1803
recycler	22.1842	(13.6836)	0	100	1803
elderly	0.1125	(0.0404)	0.0153	0.2924	1826
popden	1016.4246	(2323.3252)	1.8079	19924.7598	1826
commutein	1.2002	(3.325)	0.1302	93.119	1819
foreignr	0.0078	(0.0088)	0	0.1465	1826

Table 3: Literature survey on waste-related studies

Author(s)	Geographical focus	Waste typology	EKC evidence
Anderson et al. (2007)	EU10 and EU15	Waste generation	No
Berrens et al. (1995)	US counties	Hazardous waste	Yes
Cole et al.(1997)	OECD	Municipal waste	No
Karousakis(2009)	OECD	Municipal waste	No
Mazzanti & Zoboli(2008)	EU	Municipal waste	No
Mazzanti et al. (2009)	Italy	Municipal waste	Yes(relative)
Mazzanti & Zoboli(2009)	EU	MSW, RC, LF	No
Raymond(2004)	International Data	Waste indicator	Yes
Wang et al. (1998)	US counties	Hazardous waste	Yes

Source: Mazzanti and Zoboli (2009)

Table 4: Estimation results : municipal solid wastes and landfill

	household waste		business waste		landfill	
Variable	**Coefficient**	**(Std. Err.)**	**Coefficient**	**(Std. Err.)**	**Coefficient**	**(Std. Err.)**
`income2`	-69.6989**	(15.0449)	-17.3334	(16.8716)	-0.0096*	(0.0042)
`income`	591.8692**	(101.8226)	100.2716	(107.0932)	0.0669*	(0.0275)
`ohousehold`	464.8770**	(146.5162)	865.4055**	(136.0419)	0.1063*	(0.0474)
`elderly`	-472.1670*	(185.6922)	-1357.9000**	(152.1831)	0.0927†	(0.0543)
`commutein`	25.6109*	(10.2410)	17.6037**	(6.3031)	0.0096*	(0.0038)
`foreignr`	-1762.7261*	(783.4296)	-275.6609	(483.8492)	-0.3388*	(0.1458)
`popden`	-0.0086*	(0.0036)	-0.0068†	(0.0040)	0.0000†	(0.0000)
`lfsite`	-	-	-	-	0.0218**	(0.0025)
`Intercept`	-455.7927**	(173.5116)	41.3812	(169.6987)	-0.1197*	(0.0466)

**:1% *:5% †10%

	household waste	business waste	landfill
N	1796	1796	1796
R^2	0.1309	0.1923	0.2172
$F_{(6,1789)}$	29.6039	24.0409	16.2938

Table 5: Estimation results : recyclables

	Glass		Metal		Paper		Plastics	
Variable	**Coef.**	**(Std. Err.)**	**Coef.**	**(Std. Err.)**	**Coef.**	**(Std. Err.)**	**Coef.**	**(Std. Err.)**
`income2`	0.0001*	(0.0001)	-0.0002*	(0.0001)	-0.0037*	(0.0016)	-7.32e-06	(0.0000)
`income`	-0.0010*	(0.0004)	0.0017*	(0.0007)	0.0336**	(0.0097)	0.0001	(0.0001)
`ohousehold`	-0.0005	(0.0004)	-0.0005	(0.0005)	-0.0398**	(0.0057)	-3.28e-05	(0.0000)
`elderly`	-0.0017**	(0.0006)	0.0052	(0.0055)	-0.0098	(0.0094)	2.56e-05	(0.0001)
`commutein`	0.0000**	(0.0000)	0.0000*	(0.0000)	-0.0003**	(0.0001)	-4.81e-07	(0.0000)
`foreignr`	-0.0057**	(0.0020)	0.0003	(0.0055)	0.0917†	(0.0478)	-0.0002	(0.0004)
`popden`	0.0000	(0.0000)	0.0000	(0.0000)	0.0000**	(0.0000)	1.42e-09	(0.0000)
`lfsite`	0.0000	(0.0001)	0.0003	(0.0002)	0.0041**	(0.0008)	9.15e-06†	(0.0000)
`Intercept`	0.0024**	(0.0007)	-0.0030†	(0.0016)	-0.0486**	(0.0151)	-0.0001	(0.0001)

**:1% *:5% †10%

	Glass	Metal	Paper	Plastics
N	1796	1795	1795	1795
R^2	0.0158	0.0014	0.1678	0.001
$F_{(9,1786)}$	6.4283	2.8829	48.5443	.9677

Table 6: Turning Points

	Wasteh	Wasteb	Landfill	Metal	Paper	Glass
β_1	591.8692	100.2716	0.0669	0.0017	0.0336	-0.0010
β_2	-69.6989	-17.3334	-0.0096	-0.0002	-0.0037	0.0001
Turning Points	4.2459	2.8924	3.4844	4.25	4.54	0.06
abs. or relative	absolute	absolute	absolute	n.a.	n.a.	absolute