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## An Economic Analysis of Municipal Solid Waste Management of Toyohashi City, Japan: Evidences from Environmental Kuznets Curve

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# An Economic Analysis of Municipal Solid Waste Management of Toyohashi City, Japan: Evidences from Environmental Kuznets Curve

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## **1. Introduction:**

Rapid urbanization together with its increasing economic activities in city areas is causing greater challenges to urban environmental management. The typical structure, scale and scope of city economic development are creating uninvited impacts on the safety of the natural environment. Cities are emerging as the driving force of the economic activities and are supplying essential knowledge of production and innovation. The future cities are therefore a vital element of the global future. Understanding the relationship between city development and environmental collision is therefore critical. An important aspect of city activities is the generation of various forms of waste. Industrial, commercial, municipal activities within the city generates large scale of wastes than rural settings and becoming the most important environmental problems for cities (Buenrostro and Bocco 2003; Pokhrel and Viraraghavan 2005). Global generation of municipal solid waste in 1997 was 0.49 billion tones (Suocheng et al. 2001) and it stood at 2.02 billion tons in 2006 (Global Waste Management Market Assessment Report 2007). The link between growth in wealth and increase in waste is narrated as the more affluent a society becomes the more waste it generates (Takanori, 2008). In order to achieve sustainable growth, therefore, elimination or minimization of any negative environmental impacts resulting from economic activities is a necessary criterion.

Provisions of Waste Management and Public Cleansing Law, 1970 divide waste generated in Japan into two major categories: industrial waste and municipal waste. Local governments or the cities and towns are responsible for municipal waste treatment and each company has responsibility for industrial waste treatment. Later on in 2000, the country introduced the concept of “recycle-based society” by introducing the Basic Act for Establishing a Sound Material-Cycle Society. The two side approach of the concept performs to reduce environmental load in one hand and promote effective use of resources and energy on the other hand. The principal objective concept was establishing “End of Pipe Technology” that process the environmental load materials exhausted from human activity to reduce environmental load (Fujie, Goto, and Usui, 2001). As a result, in the line of using fossil fuel and mineral wealth for usage of economic resources and energy, resource circulation and effective use of waste heat was promoted. The well-known concept of 3R has been emphasizing since then. Material and chemical recycle, thermal recycle to collect heat and electricity as well as waste recycle is an established concept in Japan. In support of the efforts, Resource Effective Promotion Law, 2001; Food Recycling Law, 2001; Green Purchase Law, 2001; Revision Law Concerning Rational Use of Energy, 2002; and Law for Recycling of Specified Kinds of Home Appliances, 2001 were adopted by the government (Ministry of Economy, Trade and Industry, Japan, 2007). In principle, all the laws and regulations obligate local authorities or the cities and towns to implement the national

level guidelines.

This article focuses on environmental aspects of refuse municipal solid waste collection and disposal by drawing on delinking literature between per capita income and pollution of Toyohashi city, Japan. Relationship between Environmental Kuznets Curve, EKC and economic growth has been discussed in literatures such as; waste management and income can be found in Ozawa (2005), Mazzanti, et al (2009), Walls and Calcott (2005), and; Daskalopoulos et al., 1998.

## **2. Brief description of municipal waste generation in Toyohashi city**

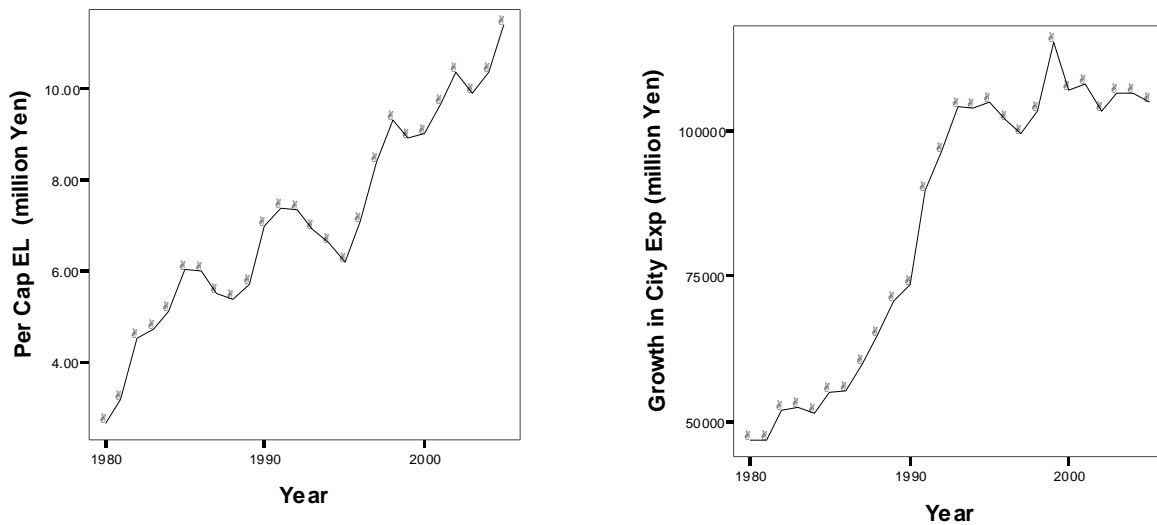
Global Warming Law, 1998 and the Kyoto Protocol Target Achievement Plan of Japan ratify 47 prefectures and 1,800 municipalities to introduce programs to address greenhouse gas emissions. About one third of the local governments adopted the national reduction target while another 40% adopted targets that go beyond the national government's 6% target (Sugiyama and Takeuchi, 2008). The guidelines of the Fundamental Law for Establishing a Sound Material-Cycle Society set a numerical target of 'material flow indexes' that identifies the overall flow of materials in the economic sector (MOE, Japan, 2009). The three aspects of the material flows are:

- (1) Inlet: Connects resource productivity ( $=\text{GDP}/\text{natural resources, etc. input}$ ) and the target value was set at JPY420,000/ton by 2015;
- (2) Cycle: cyclical use rate ( $=\text{cyclical use amount}/(\text{natural resources, etc. input}+\text{cyclical use amount})$ ) and the target value was set at 14-15% by 2015;
- (3) Outlet: final disposal amount and the target value was set at 23 millions tons by 2015 against 110 million tons of 1990 benchmark (MOE, Japan, 2006).

Generation of waste all over Japan remained flat during the years 2000 to 2006. Waste was generated roughly less than 600 million tons every year. The composition of disposal was also remained almost the same during the years. As an example, in 2006, 84.75 million tons were returned to nature (mostly waste generated in the form of animal manure, rice straw, husks, wheat straw); 29.18 million tons were disposed as final disposal (waste like paper, waste plastic, sludge, rubble, dust, and so on), and 240.7 million tons were reduced by burning (waste generated by sludge, kitchen, paper, human waste, and so on) (MOE, Japan, 2009). An amount of roughly 200 million tons were disposed off as cyclical use.

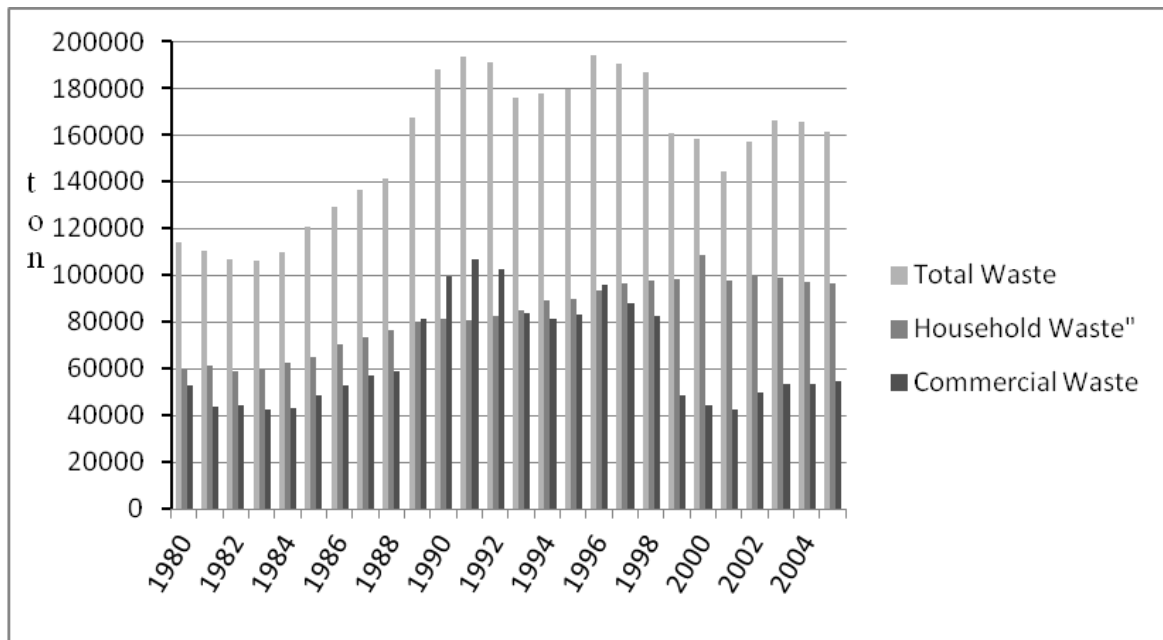
Japan has about 1,900 waste incineration facilities and 60% of them are classified as discontinuous run system incineration facility (8 hours run per day). 40% of the facilities are continuous running system facilities (16 hour run per day). By volume, only 10% of the waste processing are done by the discontinuous system. The continuous system facility represents only 20% of the total facilities but they dispose off larger amount of the waste (Kusuda, 2002). Of the 1900 incinerations, about 190 are constructed with a technology to produce electricity and in 2002 the installed power generation capacity was 1000 MW and located in 15 prefectures (NEDO, 2011).

Toyohashi city is experiencing vertical expansion as the land area remains unchanged since 1960 (Toyohashi city statistics, 2010). Mikawa port which is the biggest export and import hub for automobiles has made Toyohashi city an economically important city. Figure 1 show that during the period of 1980 to 2005, per capita economic level, EL of the city grew rapidly. In 1980, per capita EL of the city was 2.647 million yen and the figure stood at 11.409 million yen in 2005. The economic level or EL of the city has been considered by the study as a proxy variable of GDP. Reasoning of such consideration is the limitation of data at a smaller sized city in Japan. On contrary, the city spending on waste management grew steadily during the same period till 2001 and started falling from 2002. A shift in policy guidelines and technological initiatives can be regarded as the reasoning for such phenomenon.



**Figure 1. Growth in per capita EL and waste management spending of Toyohashi city over the time periods 1980-2005.**

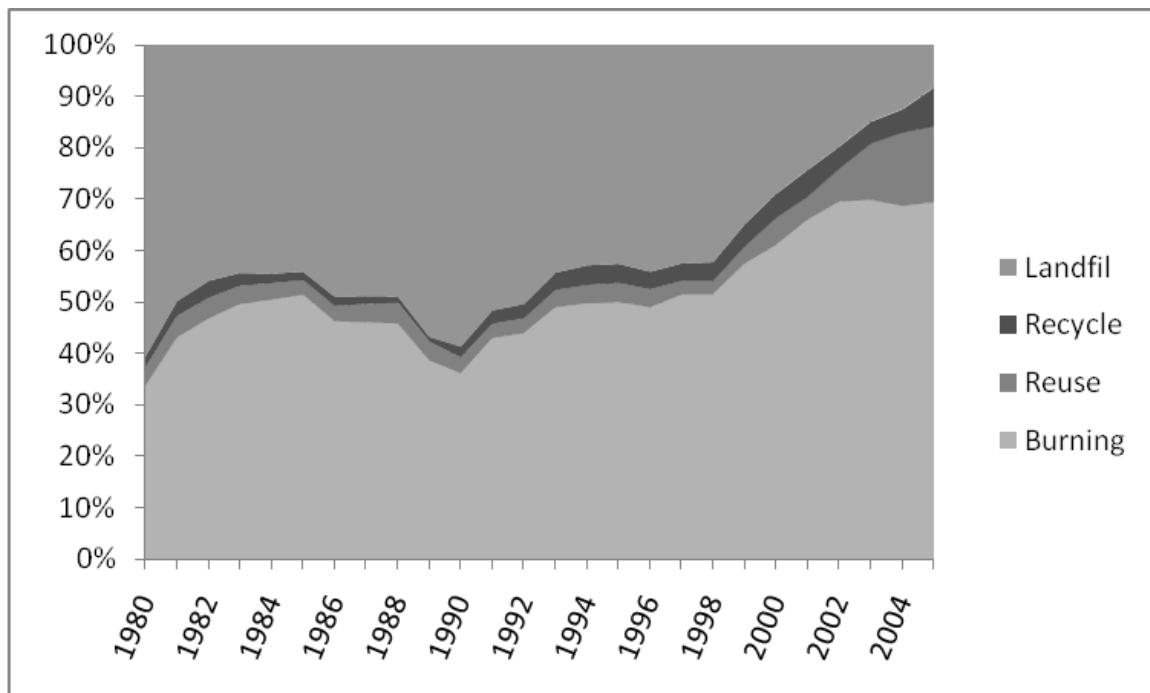
Growth in economic level, EL as well as in population growth and economic concentration triggered municipal solid waste generation in the city. Data obtained from Toyohashi city statistics show that during the periods of 1980 to 2005, municipal solid waste was generated at a higher volume until 1998. Later on a slight reduction in the waste has been observed but the figure remained higher than 1980-1989 periods.



**Figure 2. Growth of municipal waste in Toyohashi city over the time periods 1980-2005**

Toyohashi city integrated waste treatment facility was commissioned in April in 1980, and the two incinerators plant can burn 250 tonnes of waste per day. The steam-turbine generator has an output capacity of 1,500 KW (CADDET, 1995, Shimuzu, 1984). Figure 3 gives an idea of waste disposal scenerio over the periods of 1980-2005. The city statistics show that during the periods, minucipal waste diposing using reduction method was

increased and landfilling was decreased. The reuse of the waste has shown an increasing trend in recent years.



**Figure 3. Clearance of municipal waste of Toyohashi city over the time periods 1980-2005**

Clearance of municipal solid waste remains a significant challenge to the cities in Japan as situation leads to two tier problems: environmental hazards in one hand, and locating reasonable land area for waste disposal on the other hand (Sakai, et al. 2008). However, possibilities of renewable energy production could generate a better technological advantage under the changed power generation approach for Japan (Industrial Fuels and Power, 2011).

### 3. Hypothesis and estimation method:

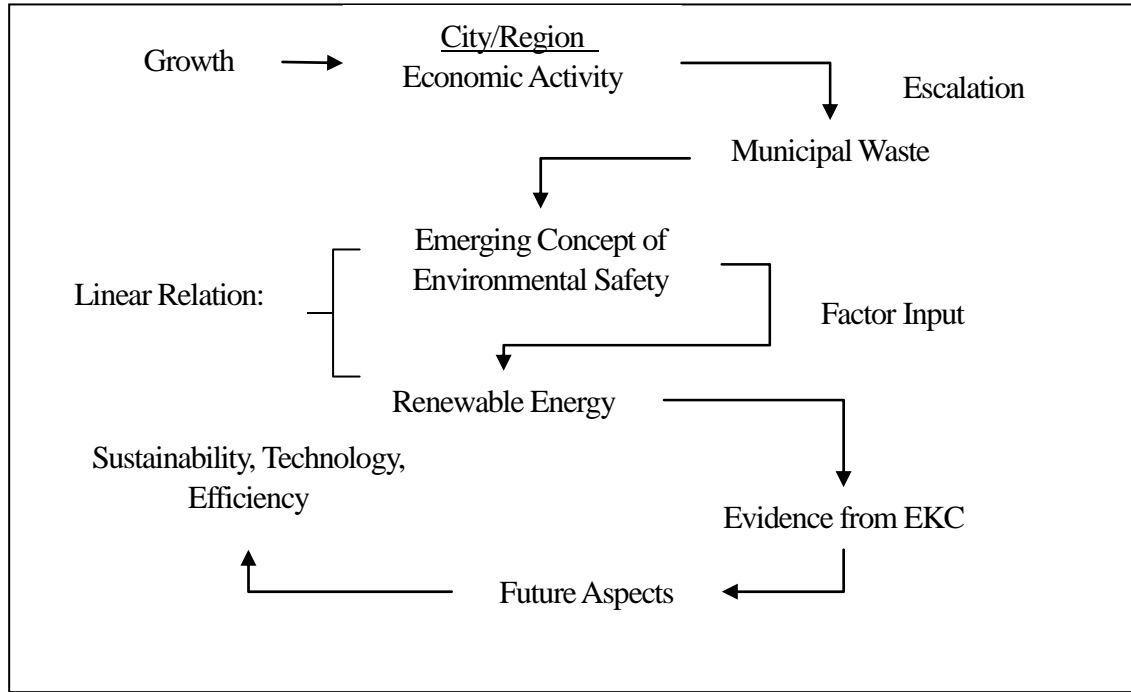
The broad objective of this paper is to find the dynamic delinking relationship between pollution or environmental damage and economic growth what is often regarded as Environmental Kuznets Curve (EKC) study. The study attempts to find the relationship between economic growth and municipal solid waste of Toyohashi city, Japan. The broad-spectrum of this paper thereby is to:

- (1) Outline economy-municipal solid waste generation and disposal pattern following growth of a city.
- (2) Investigate the scope for the city government in municipal solid waste management.
- (3) Outline potential plan for city to generate energy from municipal solid waste.

The present study aims to focus on the following research questions:

- (4) Do growths of a city economy provide aptitude to develop natural environment?
- (5) How does the city government respond to manage municipal solid waste while the city municipal solid waste generation grows?
- (6) What is the implication of national level policy decision to city waste management expenditure in Japan?

Figure 4 has been designed to present the theoretical framework of the research.



**Figure 4. Conceptual framework of the study**

It is important to know that local or city governments in Japan have implemented their own anti-environmental pollution measures based on the national guidelines. Since the nation has already achieved high level of income, its economic growth targets need not rest in higher income growth strategies, rather focuses to improve quality of life. Based on this assumption, our study aims to measure city government's initiatives to pursue better quality of life for citizens. Based on the argument above, our study takes the following hypothesis:

*Hypothesis 1: The treatment of municipal waste is well-organized in city that experience higher income and growth of the waste, and developed effective municipal solid waste disposal process.*

Since the better technological administration of municipal waste can open opportunities to produce energy, our study accounts the following hypothesis:

*Hypothesis 2: The technology of waste to power energy can be introduced to economically growing city as growth of municipal waste remains expected.*

Multiple regression models have been considered for the purpose of research. The relationship among the variables has been considered as linear. We consider the following relationship between EL, city expenditure, and municipal waste:

$$\text{Municipal Waste} \equiv f(\text{EconomicLevel}, \text{CityExpenditure}, \text{Population})$$

Using city level time series data, the ordinary least square method is applied to estimate the implication of EKC for the city. The reduced form of OLS regression equation takes the form:

$$W_i = \alpha_i + \beta_1(EL_i / P_i) + \beta_2(EL_i / P_i)^2 + \beta_3(CE_i / P_i) + \beta_4(CE_i / P_i)^2 + \varepsilon_i \quad (1)$$

where

$i$  :  $i$ -th period

$EL_i$  : economic level

$W_i$  : municipal solid waste generated

$CE_i$  : city expenditure for waste treatment

$P_i$  : population

$\epsilon_i$  : the error term

#### 4. Contribution of the Study

Examining environmental impact using Environmental Kuznets Curve has largely been accepted in North American and European researches or studies. As a result, researches based on EKC hypothesis are concentrating in Europe and North American studies. Apart from that there are some studies on China and some other Asian regions. City level EKC study is absent in case of Japanese cities. Present study, therefore, can be regarded as one of the foremost study in analyzing Japanese situation by EKC hypothesis. Moreover, study of municipal solid waste management in Japan by EKC hypothesis has not been making out earlier. The methodology to measure technological efficiency and legal intervention using EKC hypothesis can construct a new horizon for the researchers. In brief, basic contribution of the study can be:

- (1) Foremost study of a Japanese city using EKC hypothesis.
- (2) The study covers assessment of municipal solid waste generation of a city and link the effect to technological and economic growth of the city.
- (3) The study also takes into consideration local government role in Japan to ensure sustainable environment and city.
- (4) The study ties the link between national and local level commitment toward environmental safety.
- (5) This study is one of the leading studies to provide direction to future energy planning keeping environmental sustainability after the shift from energy production strategy from nuclear source.
- (6) The study will, therefore, be able to address energy planners of Japan in the changed circumstances.

#### 5. Data description

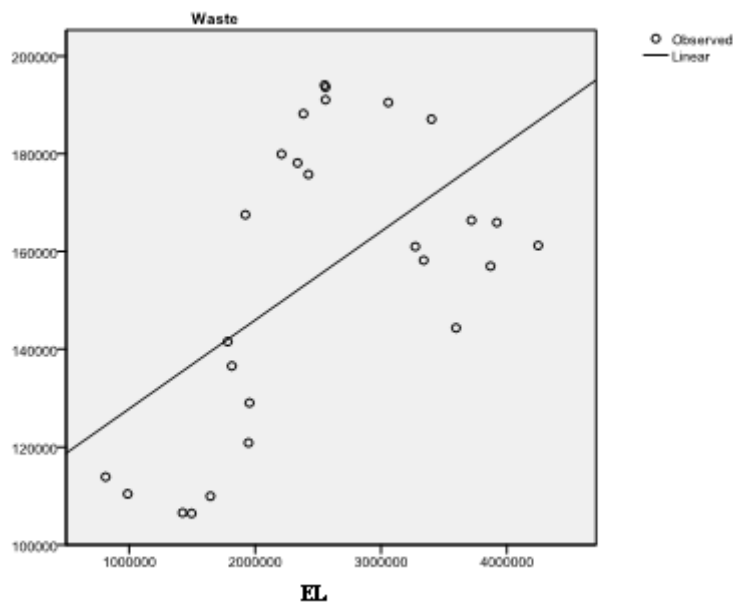
Data used in this study try to analyze empirical evidence of EKC considering per capita EL, per capita city expenditures on municipal waste management, and per capita volume of municipal solid waste generated in Toyohashi city. The explanatory variables applied for the analysis are municipal solid waste generated from households, commercial and other municipal solid waste in tons. The per capita EL was calculated based on manufacturing, agriculture and trading output of the city. Per capita city expenditure on waste management was calculated from the city accounts. The data set covers the periods from 1980 to 2005. The time series data of the study collects all the relevant data from Toyohashi city annual statistics. So in this study we have 26 year time period and we have 78 observations. The descriptive statistics of the data is shown in Table 1.

**Table 1. Descriptive Statistics and Definitions of Variables**

Variable	Definitions	Mean (SD)
Municipal Waste	Annual municipal solid waste generated by households and commercial enterprises in ton	155196.42 (30111.34)
EL	Annual per capita EL calculated from manufacturing, agriculture, trade in million yen	7.1031 (2.284)
City Expenditure for Waster Management	Annual per capita city expenditure on waste collection and treatment in thousand yen	27.7085 (13.842)

N=26

The relationship between per capita EL and municipal solid waste was found significant ( $R^2=0.94$ ) and has been shown in Figure 5. The evidence suggests that EL of the city can be explained for higher generation of municipal waste over the time periods.

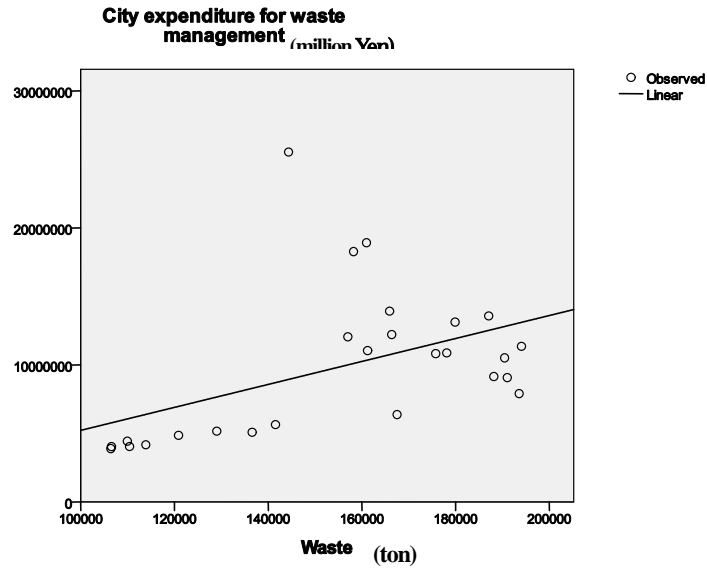


**Figure 5. Relationship between municipal solid waste and per capita EL of Toyohashi city over the time periods 1980-2005**

Waste= tons; EL= million Yen

The strong relationship between per capita CE and municipal solid waste was not found ( $R^2=0.22$ ) and has been shown in Figure 6. However, the  $t$ -statistics 2.58 implies the relationship between the two variables. The evidence suggests that municipal waste generation can be explained by the city expenditure for waste management over the time periods.





**Figure 6. Relationship between municipal solid waste and per capita city expenditure for waste management of Toyohashi city over the time periods 1980-2005**

Highlighting the growth of Toyohashi city over time, the study expects higher generation of wastes. In contrary, the study also expects that with the advancement of technology and existence of national target, the EKC for Toyohashi city would be an N-shaped one.

## 6. Empirical Results

The results of the regression analysis are provided in Table 2. The regression coefficients estimated from the time series data are statistically significant as indicated by the *t*-statistics.

The results in Table 2 revealed that per capita EL and per capita city expenditure for municipal solid waste management can be explained by the trend of higher municipal solid waste generation in the city. On the closer look, the effect of EKC hypothesis has been confirmed by the regression, as per capita  $EL^2$  and  $CE^2$  were significant. The results above are contrary to our priori expectations, and formed an inverse U-shaped EKC curve. The simulation result of the outcome is explained in Figure 7. The figure shows the EKC for the periods of 1980-2005 for Toyohashi city.

**Table 2. Regression results of the study**

Municipal Waste	
Constant	-14353.743
VAR1	21360.370*** (2.41)
VAR2	-1496.873*** (2.69)
VAR3	6198.61*** (5.04)
VAR4	-74.47*** (5.17)
R <sup>2</sup>	0.793

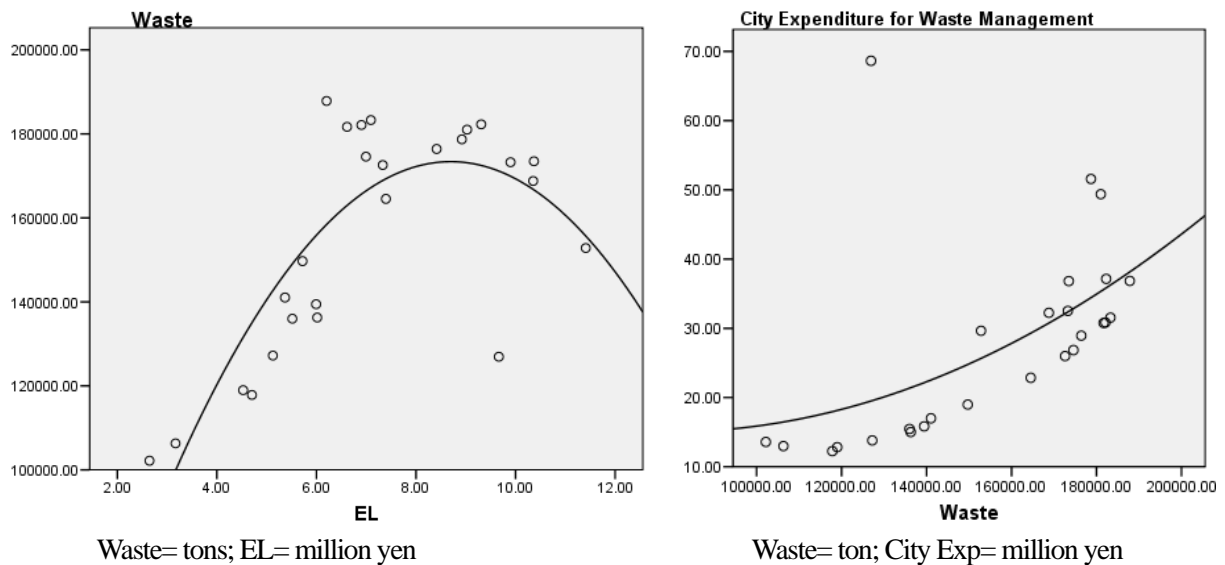
\*\*\*. Correlation is significant at the 1% (2-tailed)

\*\* Correlation is significant at the 5% (2-tailed)

\* Correlation is significant at the 10% (2-tailed)

. Numbers in the bracket denotes t-statistics

. VAR1: Per capita EL, VAR2: Per capita EL<sup>2</sup>, VAR3: CE, VAR4:CE<sup>2</sup>



**Figure 7. The effect of growth in per capita EL, per capita city spending for municipal waste management, and municipal waste generation based on EKC for Toyohashi city for the time periods of 1980 to 2005.**

Following the results of regression analysis in estimating relationship between municipal solid waste and per capita EL, city expenditure for waste management; the outcome satisfies our priori expectation. All the coefficients are statistically significant, the slope of the coefficients have expected signs. The R<sup>2</sup> value is reasonable that about 79.3% of the variation in waste generation is accounted for by the explanatory variable.

## 6. Conclusion

The study of Toyohashi city's economic growth and resultant growth in municipal solid waste management were empirically examined by

the relation between city economic growth, city expenditure for solid waste management and municipal solid waste. The growth in the economy and the population has increased the discharge of municipal solid waste in Toyohashi city. The economic size of the city is identified as a strong explanatory variable. Various kinds of municipal solid waste were generated with the city growth. Our study found that during the period of 1980 to 2005, Toyohashi city grew fast and, the disposal municipal solid waste of the city was increased as a by-product of economic activities. Such increase in solid waste disposal put in more on demand for policy and technological interventions. As a result, the city expenditures on waste management increased during the same period. The city opened its high-tech waste treatment facility in 1984. The facility provides waste to heat and power generation technology (Toyohashi city, 2011). Later on, the national concept of the sound-material based society supports the city to initiate efficient and effective municipal waste management strategy from 2001 onward (Tachibana, et al., 2008). The coefficient of economic level for generation of municipal solid waste was positive. The result denotes that the economic growth put upward pressure to the municipal solid waste generation. The negative coefficient of  $EL^2$  indicates governmental initiative to manage the municipal solid waste generation in terms of regulations and/or technology was successful in case of Toyohashi city. The coefficient of per capita city expenditures for generation of municipal solid waste was positive and the expenditure on management of the municipal solid waste grew steadily as shown in Figure 7. The result implies that the higher the waste generated, the more the city needs to spend more for waste management. The negative coefficient of per capita  $CE^2$  indicates technological and regulatory intervention was appropriate to manage the waste generated by the city. The results provide theoretical and practical significance and proposition. The growth of Toyohashi city was positively correlated to produce higher municipal solid waste while better regulatory intervention and technological improvement could end up well management of the waste generated.

The inverse U-shaped EKC for Toyohashi city proves that the relation between per capita economic level, per capita city expenditures for municipal waste management and per capita municipal solid waste can be explained by changes in national and local level initiatives accompanied by economic development and quality of life. The results follow the EKC hypothesis (Grossman and Krueger, 1995). Interpretation of such outcome is that in Japan national level policy and legal agenda reflects in local governmental level as Toyohashi city was able to improve its citizen's quality of life by addressing environmental pollutions problems by the support of higher income and better technology. The EKC of the city demonstrate that idea of sound-material based society could play a vital role in the management of the waste. Though the shape of the EKC for Toyohashi city was found inverse U-shaped, the effective national level policy intervention may not be the only reason behind. On the contrary, reduction in the volume of municipal solid waste would jeopardize waste to energy technology. A better solution of the outcome could be higher usage of the facility by extending the service to the neighboring localities. The present EKC can be viewed as the hypothesis on the interaction between economic growth, relevant spending and environmental quality. The evidence suggests an aggregate relationship between specific environmental pollutant hence municipal solid waste generation and economic level, per capita city spending on waste management. However, the shape of the relationship is not uniform across pollutant and turning points, when they exist, differ across the pollutant. In an optimistic view, the process of globalization and global economy may provide the world's development more sustainable simply by pushing the economy towards the decreasing part of the bell-shaped EKC, but the progress of research needs to learn which variable(s) have a turning point in their relation with output to draw policies to follow. A practical application was conducted to investigate relationship between the factors of municipal solid waste management and to find possible response by conducting decoupling analysis. Eco-efficiency was defined as an indicator of decoupling progress, and it was found that city spending on waste management significantly determines the eco-efficiency in Toyohashi city. This suggests importance of public

investment in pollutants as a domestic policy in the process of improving environmental sustainability. Our study also suggests that cities in Japan could play significant role in manage environmental pollutants. In achieving targets of the Kyoto Protocol, national and local governments require to play significant role (Takeuchi and Sugiyama, 2008). When a city or region grows economically; better innovation and legal framework to secure natural environmental quality is able to improved quality of life and sustainable society.

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