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The causes of the municipal solid waste and the greenhouse gas emissions from the waste sector in the United States

Seungtaek Lee, Jonghoon Kim, Wai K.O. Chong *

Arizona State University, Department of Civil, Environmental and Sustainable Engineering, 660 S. College Avenue, Tempe, AZ 85281, United States

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ABSTRACT

The United States generated approximately 730 kg of waste per capita in 2013, which is the highest amount of waste among OECD countries. The waste has adverse effects to human health and the environment. One of the most serious adverse effects is greenhouse gas emissions, especially methane (CH_4), which causes global warming. However, the United States' amount of waste generation is not decreasing, and the recycling rate is only 26%, which is lower than other OECD countries. In order to decrease waste generation and greenhouse gas emissions, identifying the causality of the waste generation and greenhouse gas emissions from waste sector should be made a priority. The research objective is to verify whether the Environmental Kuznets Curve relationship is supported for waste generation and GDP across the U.S. Moreover, it also confirmed that total waste generation and recycling of waste influences carbon dioxide emissions from the waste sector. Based on the results, critical insight and suggestions were offered to policymakers, which is the potential way to lower the solid waste and greenhouse gas emissions from the waste sector. This research used annually based U.S. data from 1990 to 2012, and these data were collected from various data sources. To verify the causal relationship, the Granger causality test was applied. The results showed that there is no causality between GDP and waste generation, but total waste and recycling generate significantly increasing and decreasing greenhouse gas emissions from the waste sector, respectively. This implies that waste generation will not decrease even if GDP increases. And, if waste generation decreases or the recycling rate increases, greenhouse gas emission will decrease. Based on these results, increasing the recycling rate is first suggested. The second suggestion is to break the causal relationship between MSW and greenhouse gas emission from the waste sector. The third is that the U.S. government should benchmark a successful case of waste management. Based on the research, it is expected that waste generation and carbon dioxide emission from the waste sector can be decreased more efficiently.

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1. Introduction

Global Municipal Solid Waste (MSW) amounts to approximately 1.3 billion tons per year and is expected to increase to approximately 2.2 billion tons per year by 2025 (Hoornweg and Bhada-Tata, 2012). Waste generation in Organization for Economic Cooperation and Development (OECD) countries has increased approximately 14% from 1990 up to now (OECD, 2006). In the case of the United States, the U.S. generates the most waste per capita compared to other OECD countries—approximately 730 kg per capita in 2013 (OECD, 2013). Since 1960, the United States' total municipal solid waste generation has increased 288% (EPA, 2015). Moreover, the U.S. produced the most greenhouse gas emissions compared to other OECD countries (OECD, 2013). Based on an U.S. Environmental Protection Agency (EPA) study in 2014, 117.2 Tg CO_2 Eq. of methane (CH_4) was emitted from waste in the United States. Approximately 18.1% of total U.S. methane emissions were generated from the waste landfills sector in 2013, which is the third largest contribution of methane emission in the United States (Agency, 2014).

Solid waste, which has reactivity, toxicity, explosiveness, erosive, or other characteristics, can result in adverse effects to human health and the environment (Alam and Ahmade, 2013). In particular, waste produces a large amount of greenhouse gas emissions, which is the most critical issue affecting changes to global climate (Bogner et al., 2008). As the amount of GHGs increase in the atmosphere, increased solar heat will be trapped in the gas and, therefore, atmospheric temperatures will continue to increase

* Corresponding author.
E-mail addresses: slee345@asu.edu (S. Lee), ghim96@gmail.com (J. Kim), Oswald.Chong@asu.edu (W.K.O. Chong).

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(Calabrò, 2009; Miah et al., 2011). The best way to reduce the impacts of global warming is by reducing greenhouse gas emissions. According to the Intergovernmental Panel on Climate Change (IPCC), global surface temperature will increase by 4.8 °C and sea levels by 0.82 m by 2100 (IPCC, 2014). In addition, the climate change originating from greenhouse gas will drop between 5% and 20% of the annual global GDP if the greenhouse gas does not decrease immediately. Therefore, reduction of greenhouse gas is a critical issue to be resolved.

Several efforts to reduce waste have been made in the past by the U.S. government. In 1976, the Resource Conservation and Recovery Act (RCRA) gave the EPA the authority to manage hazardous waste, which includes its generation, transportation, treatment, storage and disposal. In 1984, the Federal Hazardous and Solid Waste (FHSW) amendments to RCRA focused on waste minimization and phasing out land disposal of hazardous waste (Barke, 1985; U.S. Congress Office of Technology Assessment, 1983). Moreover, according to the Weitz et al. (2002), the U.S. communities' appropriate actions, such as technological advancements, environmental regulations, and emphasis on resource conservation and recovery, have significantly reduced the environmental impacts of municipal solid waste, including greenhouse gas emissions. However, solid waste generation is not decreasing and the recycling rate is not increasing. The U.S. recycling rate is only 26%, and it is lower than other OECD countries (http://www.oecd.org/). Americans on average recycled and composted 0.68 kg out of an individual waste generation rate of 2 kg per person per day (EPA, 2015). The highest recycling rate among OECD countries is found in South Korea, which is almost 60% (http://www.oecd.org/). South Korea started implementing recycle performance measures in 1995 (Park and Lah, 2015).

The current situation of the U.S. waste sector is severe. Not only the waste generation per capita, but also the greenhouse gas emissions from the waste sector are significantly high. Thus, the main objective of this research is to mitigate the solid waste and greenhouse gases from waste sector. In order to achieve the main objective, first, we investigated the causal relationship with solid waste across the U.S. If the main cause of the solid waste is verified, the waste can be decreased effectively. Second, it is confirmed that the solid waste and recycling waste influence greenhouse gas emissions from the waste sector. By verifying the relationship between the waste and greenhouse gas from the waste sector, appropriate strategies can be developed for decreasing the greenhouse gas from the waste sector. Lastly, based on the research results, we provide important insights and suggestions to policymakers on potential ways to reduce the solid waste and greenhouse gas emissions from the waste sector. The rest of this paper is organized as follows: Section 2 reviews the related previous literature, Section 3 presents the methodology used in this research and research results, Section 4 discusses the research results, and Section 5 is the conclusion.

2. Literature review

The solid waste generation per capita can be correlated to Gross Domestic Production (GDP) per capita. According to the previous research, environmental degradations that include municipal waste per capita, greenhouse gas emissions per capita, dissolved oxygen in rivers, and change in forest area relate to GDP per capita, and this relationship is called the Environmental Kuznets Curve (EKC) (Stern et al., 1996). The EKC hypothesis is that there is an inverted-U relationship between per capita income and environmental degradation (Stern et al., 1996). This hypothesis conjectures that initially environmental degradation tends to get worse as per capita income rises until it reaches a certain level and the degradation subsides and drops at the highest economic level (Shafik, 1994; Stern et al., 1996). Thus, economic growth may become a solution rather than a source of the problem (Rothman and Bruyn, 1998). There have been a lot of studies of the ECK relationship. Most of the studies focused on the relationship between economic growth per capita and carbon dioxide emissions for various countries, and the research showed different results depend on the country. (Apergis and Payne, 2014; Bölük and Mert, 2014; Kivyiro and Arminen, 2014; Omri and Nguyen, 2014; Shafiei and Salim, 2014; Omri, 2013; Arouri et al., 2012; Jayanthakumaran et al., 2012; Saboori et al., 2012; Acaravci and Ozturk, 2010; Dinda and Coondoo, 2006).

Among the previous studies, several studies tried to verify whether or not the EKC relationship exists in the United States. Some studies confirmed that the United States has the EKC relationship for environmental degradation factors. Roach (2013) concluded that the United States has the EKC relationship at the state level for carbon dioxide emissions. Gawande et al. (2000) verified the EKC relationship for hazardous waste in the United States. List and Gallet (1999) provided initial evidence that states' NO_X and SO_2 emissions have followed an inverted-U shape relationship. However, other research has showed different results. Soytas et al. (2007) concluded that there is no EKC relationship in the case of the U.S. for carbon dioxide emission. Cole et al. (1997) suggested that municipal waste of OECD countries does not have significant EKC relationship. Some prior research analyzed the relationship between the waste and GDP in some countries. Mazzanti (2008) and Mazzanti et al. (2008) concluded that there is de-linking of waste generation from economic growth in Italy. However, in Bangladesh, it was shown that the EKC relationship is supported for waste and greenhouse gas emissions from waste.

There have been various prior studies, however, the studies have some limitations, so additional research is essential. First of all, most previous studies usually focused on carbon dioxide emissions when analyzing the EKC relationship. However, there are various other environmental degradation factors, and municipal solid waste is one of the degradation factors that is most deadly to environment. Second, there is insufficient EKC and municipal solid waste research in the United States. As shown in the previous research, depending on the environmental degradation factors or countries, the relationships either exist or they do not. Moreover, there is insufficient research about the causal relationship between municipal solid waste, recycling waste generation, and greenhouse gas emission. Thus, this research focused on municipal solid waste in the United States and verified the causality between the factors.

3. Methodology and empirical results

3.1. Data collection

Two causality models are proposed for achieving the research objectives. The first model is for the EKC relationship, which verifies whether or not there is inverse proportion between GDP per capita and MSW generation per capita. The U.S. annual data from 1990 to 2012 used in this study were collected from various data sources. The GDP per capita (current U.S. dollar) and municipal solid waste generated per capita (kilograms per capita), which is comprised of various items such as packaging, furniture, electrical appliances, and food waste, but does not include industrial, hazardous, or construction waste, were collected from the World Bank website database (http://www.worldbank.org/) and OECD website database (http://stats.oecd.org/) for the first model. The second model confirms how the total MSW and recovery waste, which is selectively extracted materials from disposed waste for next use and includes recycling and composting waste generation, causes

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