A Comparative Study on Economic Policies for Construction and Demolition Waste Minimisation

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ABSTRACT

The amount of solid waste generated in construction and demolition (C&D) processes is massive. Therefore, many countries and cities have established various economic policies to reduce C&D waste, which include waste disposal charge, deposit-refund scheme, tax on materials, and fine scheme. Appropriate economic policies can motivate the construction industry to minimise C&D waste. There are differences in economic policies adopted by various countries and cities. However, studies that compare the economic policies for C&D waste minimisation in various countries and cities are currently lacking. Therefore, this paper aims to quantitatively and qualitatively compare the economic policies implemented for C&D waste minimisation in Hong Kong, South Korea, the US, the UK, Ireland, the Netherlands. To understand the impacts of the economic policies on C&D waste minimisation, C&D statistical data are also analysed. Based on the comparative study, this paper will discuss the relationships between the economic policies and C&D waste. Recommendations on economic policies for C&D waste minimisation will also be provided.

Keywords: *construction and demolition (C&D) waste, economic policy, waste management*

1. INTRODUCTION

The amount of solid waste generated in construction and demolition (C&D) processes is massive. For example, C&D waste contributes 25% of solid waste disposed of at landfills in Hong Kong (HKEPD, 2015), 26% in the US (USEPD, 2009), and 47% in South Korea (ME and KECO, 2014). Therefore, many regions such as Hong Kong (HKEPD, 2015) and the US (ESD, 2012) have established various economic policies to reduce C&D waste. Appropriate economic policies can motivate the construction industry to minimise C&D waste (Li, 2013). Economic policies include waste disposal charge, deposit-refund scheme, tax on materials, and fine scheme (Li, 2013). There are differences in economic policies adopted by various countries and cities. For example, a high landfill tax is charged at USD 176 per tonne in Germany, which is 11 times as expensive as the construction waste disposal charge in Hong Kong. However, studies that compare the economic policies for C&D waste minimisation in various regions are currently lacking. Therefore, this paper aims to quantitatively and qualitatively compare the economic policies implemented for C&D waste minimisation in the Asia Pacific, North American, and European regions because they are the largest construction markets (IHS, 2013). Specifically, Hong Kong, South Korea, the US, the UK, Ireland, and the Netherlands were studied in this paper. The details of economic policies to be investigated include establishment and modification years of economic policies, waste disposal facilities, classification of waste types, and charges for each waste type. To understand the impacts of the economic policies on C&D waste minimisation, solid waste and C&D waste generated per capita and C&D waste generation rates are analysed as well.

The next section introduces the economic policies for C&D waste minimisation in the six regions, and investigates and compares them quantitatively and qualitatively. Section 3 compares previous and current C&D waste statistical data of each region. Section 4 discusses the findings, followed by conclusion in Section 5.

2. ECONOMIC POLICIES FOR C&D WASTE MINIMISATION

This section introduced and compared the economic policies for C&D waste minimisation in Hong Kong, South Korea, the US, the UK, Ireland, and the Netherlands.

2.1 Economic policies for C&D waste minimisation

The economic policies cover deposit-refunded scheme, fines scheme, charging scheme (or landfill levy), and tax on raw materials (Li, 2013). Deposit-refunded scheme means that the deposit is refunded when the specific requirements are fulfilled. The scheme reduces the incentive to illegal dumping and stimulates reuse and recycling of waste streams. In construction and demolition diversion deposit (CDDD) in the US, the deposit is based on construction type, project size, and project value. Fines are charged for non-compliance such as illegal dumping and low recycling rates. The charging scheme charges construction waste generation in order to reduce the amount of C&D waste disposed of at landfills. Many countries and regions have adopted this scheme. Tax on raw materials is a financial measure by shifting the price differential against raw materials and in favour of secondary materials, in order to reduce resource extraction, to increase recycling rates, and to make full use of secondary materials.

2.2 Comparison of economic policies

Establishment and modification years of the four types of the economic policies were investigated and compared in this study. Data on the economic policies for C&D waste minimisation in the six regions were collected from previous studies (Oosterhuis et al., 2009, EIONET, 2009, HKEPD, 2012, ESD, 2012), as shown in Table 1. Although there are no economic policies for C&D waste management and minimisation in South Korea, the waste management law introduced for solid waste in South Korea in 1986 was used for C&D waste as well (KECO, 2016).

A deposit-refunded scheme (in 2001) and fines scheme (in 2006) were established in the US. In terms of the deposit-refunded scheme, CDDD of the County of San Diego (ESD, 2012) was effective in 2007 with the requirement of 90% of inert waste and 70% of other waste diverted from landfill. Four regions such as Hong Kong, the US, the UK, and the Netherlands established tax on raw materials. Moreover, tax on raw materials is also adopted by most of European countries such as Denmark, Sweden, Belgium, and Italy (Eunomia et al., 2009).

Region (reference)	Economic policies (year)			
	Charging scheme	Deposit-refunded scheme	Tax on raw materials	Fines scheme
Hong Kong (HKEPD, 2012)	2006	-	2001	-
South Korea (KECO, 2016)	1993[a)] (2008[a)b)])	-	-	-
US (ESD, 2012)	1989	2001 2007 (San Diego)	1998	2006
UK (EIONET, 2009)	1996	-	2002	-
Ireland (EIONET, 2009)	2002 (2008[b)])	-	-	-
Netherlands (Oosterhuis et al., 2009, EIONET, 2009)	1996	-	1997	-

a) Denotes the establishment or modification year for solid waste
b) Denotes the modification year

Table 1: Comparison of economic policies for C&D waste minimisation in six regions

Interestingly, the UK has a progressive landfill tax, which means the tax rate rises each year, to enhance the awareness of waste reduction and divert waste from landfill (Tojo et al., 2006). Since there are big differences in the charging schemes adopted by various countries and cities, C&D waste charging schemes in the six regions are quantitatively compared in the next sub-section.

2.3 Comparison of C&D waste charging schemes

C&D waste charging can be categorized by waste type and waste treatment facility type according to charging schemes, as shown in Table 2. For example, in Hong Kong, C&D waste is classified into inert waste and non-inert waste by waste material. Inert construction waste contains rock, rubble, boulder, earth, soil, sand, concrete, asphalt, brick, tile, masonry, and used bentonite (HKEPD, 2013). In other regions such as South Korea and the Netherlands, C&D waste is categorized into combustible and non-combustible waste (Gritten, 2007). In the Netherlands,

combustible waste that can be recovered is prohibited to dispose of in landfills. Depending on the C&D waste types, C&D waste is disposed of in other types of facilities, including landfills, public fills, sorting facilities, and incineration facilities. Table 2 shows the comparison results of charging schemes in the six regions, including C&D waste types, facility types, charging fee, and ratios of charging fee.

C&D waste disposal cost at landfills in the UK (USD 107.7) is the most expensive, followed by the US (USD 74.0), the Netherlands (USD 70.8), South Korea (USD 46.1), and Ireland (USD 26.0). The C&D waste disposal cost at landfills in Hong Kong (USD 16.4) is the cheapest among the six regions, which is 15.2% of that in the UK. On the other hand, the disposal cost at public fills in the UK and Hong Kong are cheap. The incineration of construction waste in South Korea is the most expensive method.

Country (Reference)	C&D waste type	Facility type	Charing fee (USD/tonne)	Ratio (%)
Hong Kong (HKEPD, 2012)	Less than 50% inert waste	Landfill	16.4	15.2
	Inert waste	Public fill	3.5	3.2
	More than 50% inert waste	Sorting facilities	12.9	12.0
South Korea (Lee and Dong, 2016)	Mixed waste	Landfill	46.1	42.8
	Recyclable waste	Sorting facilities	67.3*	62.4
	Combustible	Incineration	134.5*	124.9
US (ESD, 2012)	Mixed waste	Landfill	74.0	68.7
	Recyclable concrete	-	10.0	9.3
UK (UKGov, 2006)	Mixed waste	Landfill	107.7	100.0
	Sorted waste (rock or soil)	Public fill	3.2	3.0
Ireland (Li, 2013)	-	Landfill	26.0	24.1
Netherlands (Van Dijk et al., 2001)	Non-combustible	-	13.9	12.9
	Combustible	-	70.8	65.7

* Is the average value of charging fee

Table 2: Comparison of charging schemes in the six regions

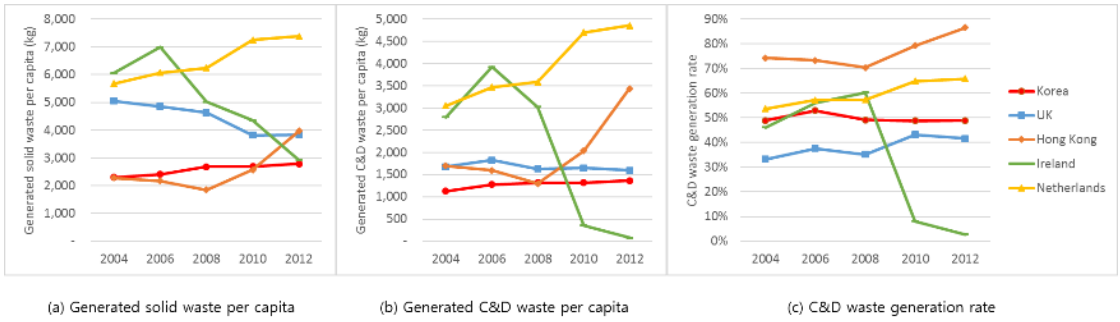
3. ANALYSIS OF C&D WASTE STATISTICS

In order to understand the current status of C&D waste generation and the impacts of the economic policies on waste minimisation in the six regions, their C&D waste statistical data were collected, analysed, and compared. This paper analysed data on (1) the amount of generated solid waste per capita, (2) the amount of generated C&D waste per capita, and (3) C&D waste generation rates.

In order to analyse the amount of generated solid waste and C&D waste per capita in each region, data on the amount of generated solid waste and C&D waste and population in each region should be collected. In this paper, data on the amount of solid waste and C&D waste were obtained from database of HKEPD (2015), ME and KECO (2014), and Eurostat (2016) for Hong Kong, South Korea, and the UK, Ireland, and the Netherlands, respectively. However, since Eurostat has provided waste information during the period from 2004 to 2012, this paper analysed trends of generated C&D waste per capita for 12 years. Population data in South Korea, the UK, Ireland, and the Netherlands were collected from the Organization for Economic Co-operation and Development (OECD) Structural Analysis (STAN) database (OECD, 2016). Population data in Hong Kong were collected from the database of the Census and Statistics Department of Hong Kong (HKCSD, 2016).

Figure 1 shows the trends of (a) Generated solid waste per capita, (b) Generated C&D waste per capita, and (c) C&D waste generation rates in the six regions during the period from 2004 to 2012. However, since data on the amounts of solid waste and C&D waste in the US were not officially provided, the results of the US could not be investigated and compared. As a result, the amount of generated C&D waste per capita in the Netherlands (average: 3,930kg) was generally larger than those in Ireland (2,033kg), Hong Kong (2,011kg), the UK (1,674kg), and South Korea (1,279kg), in spite of high recycling rates of C&D waste (around 99% in the Netherlands (Gritten, 2007)). The amount of generated C&D waste per capita increased in the Netherlands (159%), Hong Kong (203%), and South Korea (121%) during the periods from 2004 to 2012, while those in the UK (95%) and Ireland (3%) decreased during the period. Interestingly, generated C&D waste per capita in Hong Kong has rapidly increased since 2008, while that in Ireland has rapidly decreased since 2006 although generated C&D waste per capita in Ireland in 2006 was the highest among the six regions. The C&D waste charging schemes in Hong Kong and

Ireland were released or modified in 2006 and in 2008, respectively, and they had positive impacts on C&D waste reduction at the time the schemes were released or modified in each region. Especially, generated C&D waste per capita in Ireland in 2012 was around 2 % of that in 2006. On the other hand, although generated C&D waste per capita in Hong Kong in 2008 was 77% of that in 2004, that in 2012 increased by 2.6 times as compared with that in 2008. According to previous studies (Lu, 2013, Lu and Tam, 2013, Yu et al., 2013, Hao et al., 2008), the C&D waste charging scheme in Hong Kong helped to reduce the amount of C&D waste generated for the first three years (2006 to 2008); however, the impacts of the charging scheme was low since 2008 because of low C&D waste disposal cost. The most expensive cost for disposal of C&D waste in the UK can be a reason of the slight decrease in the amount of C&D waste generation in the UK. Another reason is the annual increase of C&D waste disposal cost in the UK year by year.



(a) Generated solid waste per capita (b) Generated C&D waste per capita (c) C&D waste generation rate

Figure 1: Trends of solid waste and C&D waste generation per capita in the six regions (2004, 2006, 2008, 2010, and 2012)

Although time-based trends of the amount of generated C&D waste per capita in the six regions were similar to those of generated solid waste per capita and of C&D waste generation rates, the orders of C&D waste generation rates in the six regions were slightly different from that of generated C&D waste per capita. In terms of C&D waste generation rates, Hong Kong (average: 77%) was the highest, followed by the Netherlands (60%), South Korea (48%), the UK (38%), and Ireland (35%). The C&D waste generation rates in the UK (125%), the Netherlands (123%), and Hong Kong (127%) increased unlike those in South Korea (100%) and Ireland (6%).

4. DISCUSSION

According to the results of this study and previous studies (Li, 2013), disposal cost of C&D waste had positive impacts on C&D waste reduction. Therefore, appropriate adjustment of disposal cost of C&D waste can motivate practitioners to efficiently minimise and manage C&D waste on site. Referring to the policy in the UK, an annual increase of the disposal fee year by year helps to decrease the amount of C&D waste generation. In Hong Kong, the charges for C&D waste disposal will be increased with effect from April 2017 to reduce the amount of generated and disposed C&D waste. Public fill charge, sorting charge, and landfill charge in Hong Kong are proposed to be increased to USD 9.2, 22.6, and 25.8 (263%, 175%, and 160% of charges of the current C&D waste disposal charging scheme in Hong Kong), respectively (HKEPD, 2016)

In order to efficiently minimise C&D waste, quantified goals, such as setting limits on the amount of total C&D waste being sent to landfills, setting recycling rates for C&D waste, etc., are required. The Department for Environment, Food, and Rural Affairs (DEFRA) in the UK has attempted to achieve zero construction waste to be disposed of at landfills by 2020 (Ismam and Ismail, 2014). The UK already exceeded the 2020 reduction target of recovering at least 70% by weight of inert C&D waste (DEFRA, 2013). Additionally, the impacts of economic policies on C&D waste reduction should be continuously monitored by investigating time-trends of C&D waste generation and disposal.

A comprehensive C&D waste composition study should be conducted so as to be aware of the current quantities of each C&D waste material type. Not only sorting inert and non-inert materials or combustible and non-combustible materials, a more detailed breakdown is necessary to identify which material type is in majority and which type should be mainly managed. The study should be carried out periodically in order to keep the data most up to date so that it can reflect recycling performance of different C&D waste materials as well as changes of disposal patterns because of established and modified economic policies for C&D waste minimisation. The collected data could also help the government to propose possible future scenarios and required capacities.

5. CONCLUSIONS

This paper quantitatively and qualitatively investigated and compared the economic policies for C&D waste minimisation in Hong Kong, South Korea, the US, the UK, Ireland, and the Netherlands. Four types of economic policies, namely deposit-refunded scheme, fines scheme, charging scheme (or landfill levy), and tax on raw materials, were compared. In terms of charging schemes, there are big differences among the six regions. Tax on raw materials and charging schemes are used as economic policies for C&D waste minimisation in the investigated regions. The disposal cost at landfills in Hong Kong is around 15% of that in the UK. Comparing results of C&D waste statistics in Hong Kong, the UK, and Ireland, this study finds that high disposal cost, annual increase of disposal cost, and establishment or modification of C&D waste charging schemes have positive impacts on C&D waste minimisation. However, impacts of low disposal cost for C&D waste in Hong Kong on C&D waste reduction did not last for a long period, but in Ireland, generated C&D waste per capita in 2012 decreased by 2% of that in 2006.

However, due to the limitations of data collection in this study, relationships between the economic policies and the amount of C&D waste were not analysed quantitatively and other factors can affect the C&D waste statistics as well. Therefore, in the future, the relationships will be analysed using statistical methods.

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