Revisiting the extended producer responsibility program for metal packaging in South Korea

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1. Introduction

Faced with increasing waste generation, most OECD countries now implement extended producer responsibility (EPR) policies in key sectors (OECD and The Japanese Ministry of the Environment (MOEJ, 2014). The OECD defines EPR as an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle (OECD, 2001). The OECD (2007) introduced EPR as one of the tools for Environmentally Sound Management of Waste. Emerging economies in Asia, Africa and South America have also started to develop EPR programs in recent years (Manomaivibool and Hong, 2014).

The original concept of EPR places emphasis on environmentally compatible product design as a way to minimize wastes at the source (Lindhqvist, 2000; Walls, 2006). Recycling itself is not treated as an objective. In developing countries, however, EPR is often viewed as a direct governmental intervention to promote recycling (Manomaivibool, 2011).

In 1991, South Korea implemented the waste deposit recycling (WDR) program as a system that imposed a charge for certain products. The WDR program was intended not only to finance waste management but also to divert certain materials from the mixed municipal waste stream. A shortage of landfill sites was the main driver of this initiative according to the South Korean Ministry of Environment (MOE, 1992). The WDR program imposed a charge on packaging materials and household appliances (air conditioner, refrigerator, television, and washing machine). Producers of regulated packaging and products paid the charge in accordance with the products they sold in the previous year. A portion of the charge was refunded to producers of regulated packaging and products in accordance with the amount of recycling.

However, the WDR program has caused political hardship when the rates were raised (Shin, 1995). Producers of regulated packaging and products claimed that the product charges had weakened their competitiveness (Kim et al., 2006) and that the government should be held accountable in its use of the revenues raised from product charges (Lee, 2010). The WDR program was evaluated as being effective in reducing waste from metal packaging and glass (Kim et al.,

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Abbreviations: EPR, extended producer responsibility; KMCRA, Korea Metal Cans Resources Association; WDR, waste deposit recycling; CBA, cost-benefit analysis; MOE, Ministry of Environment; MOEJ, Ministry of the Environment, Japan; KEI, Korea Environment Institute; KOSIS, Korean Statistical Information Service; KECO, Korea Environment Corporation.

2006) but not home appliances (Manomaivibool and Hong, 2014). Opposition from industry and insufficient recycling performance for some products led the government to replace WDR program with the EPR program in 2003. The EPR program was backed by the OECD's Recommendation of the Council on the Environmentally Sound Management of Waste (OECD, 2007). To date EPR is the leading instrument for packaging waste management in Korea.

In Korea, the EPR program requires mandatory recycling with binding targets and fines for noncompliance. The program's objectives are waste reduction and cost minimization through recycling (Park, 2006).

In the years since the EPR program replaced the WDR program, a few comparative analyses between the programs have been conducted. However, these evaluations were qualitative and have not shown quantitatively whether the change has increased benefits.

Against this background, this paper aims to explore which program brings larger net benefits. A cost-benefit table is employed with landfill disposal taken as a baseline. Because of limited data availability, this paper focuses on metal packaging exclusively.

2. Previous research

Cost-benefit analysis (CBA) is a technique that compares the costs and benefits to society of providing a public good. Sturges (2003) advocated CBA as a tool for evaluating EPR programs. Smith (2005) constructed an analytical framework for the CBA of EPR programs.

There are two types of CBAs for waste management programs: financial and environmental assessment. Integrated financial and environmental assessments have been conducted by Bruvoll (1998), Eriksson et al. (2005), Hosoyamada et al.(2003), Ibenholt and Lindhjem (2003), Morris (2005), Nolan-ITU et al. (2001), RDC and Pira (2003), Reich (2005), and Vigsø (2004).

Other research has conducted either financial assessment (Begum et al., 2006; KECO, 2011; Leu and Li, 1998; Oh, 2003) or environmental assessment (Craighill and Powell, 1996).

The Korea Environment Corporation (KECO, 2011) conducted a financial assessment of Korea's EPR program in comparison with landfill disposal during 2003-2011. KECO found the total benefits of the EPR program have outweighed the total costs since 2003. However, this study underestimated the costs, as it did not include collection costs.

Oh (2003) conducted a financial assessment on the waste management of plastic packaging in Seoul, and compared two EPR policy alternatives against the WDR program: One where producers pay the costs for the collection, transport, and recycling of plastic packaging, and one where producers pay for only transport and recycling costs. Oh found that the net benefits of the WDR program are positive for only the first policy option. However, these two policy options are quite different from the current EPR policy, and thus, do not hold practical implications for the current EPR program.

Lavee (2010) and Hosoyamada et al. (2003) conducted environmental assessments, but focused on only electricity consumption and CO_2 emissions, respectively. Others researchers have covered wider social impacts in their environmental assessments: traffic accidents, congestion, and noise (Nolan-ITU et al., 2001); disamenity of landfills (RDC and Pira, 2003); and time value spent

by households sorting garbage (Ibenholt and Lindhjem, 2003).

In Korea, there has been no CBA of the EPR program based on environmental assessments. One reason is insufficient data on environmental impacts and economic valuation. Data on environmental impacts from the collection and transport of households refuse and recyclable wastes by municipalities are available (Oh et al., 2008) but do not cover final disposal such as landfill and incineration. With respect to the recycling stage, Gwak et al. (1998) conducted the only research that employs life cycle assessment of beverage cans throughout the whole lifecycle from manufacturing to recycling in comparison with landfill disposal. That study found climate change and ocean acidification to be the dominant environmental impacts. However, valuation of these environmental impacts is not available. Baek et al. (2011) evaluated the environmental impacts of the manufacturing stage of aluminum cans in which recovered material is used, but the recycling stage was not included.

Sturges (2003) has advocated CBA focused on environmental assessment. This is the only analytical framework that allows the optimal recycling level of a recycling program to be presented. However, this framework is difficult to apply in Korea because of the lack of data for defining the environmental impacts of the WDR and EPR programs in monetary terms. Meanwhile, Smith (2005) provided a framework for showing the performance of the EPR program against a counterfactual baseline. This is why the CBA framework of Smith (2005) is used in this paper, with a main focus on comparing financial assessments between the WDR and EPR programs, particularly the landfill savings targeted by these two policies.

3. Description of WDR and EPR programs

3.1. Theory

South Korea's WDR program for metal packaging differs from conventional deposit refund programs that place a surcharge on a product when purchased by consumers and issues a rebate when the packaging is returned. In South Korea, the government imposed a product charge on producers in proportion to their production output. The program had no mechanism to pass the refund from producers/retailers to consumers. Instead, producers received part of the total deposit from the government once discarded metal packaging was recycled.

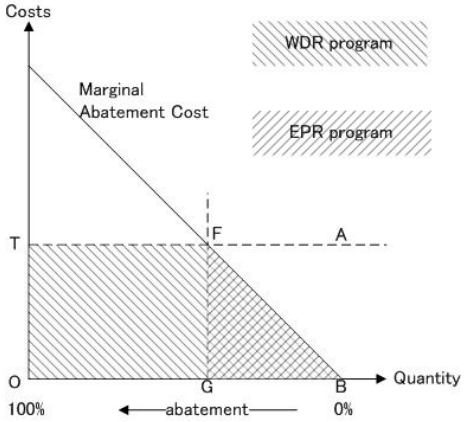

Fig. 1. Producers' recycling costs in the WDR and EPR programs

In Fig. 1, if the deposit rate in the WDR program corresponds to line segment OT, producers should make a deposit to the government in advance; the deposit corresponds to the area enclosed by OTAB. When the deposit and refund rates correspond to line segment OT, producers recycle up to line segment BG, because BG is the recycling level where the cost incurred by producers becomes minimal. In this case, GFAB is returned to producers later. However, producers eventually bear the cost of OTFB, given by the shaded area, because the area of triangle BFG is also part of the producers' costs for recycling. OTFG is unreturned and supposed to be used by the government to undertake environmental measures, including establishing recycling infrastructure (Lee, 2004). The government raised the deposit rate OT gradually in order to increase recycling volumes.

In the EPR programs, the government imposes a recycling quota on producers. If the quota is not met, a fine that is greater than the cost of implementing proper recycling is imposed on the producers (KECO, 2010). Fig. 1 shows that if the allocated recycling quota in the EPR program is BG, producers bear the cost only for the area of triangle BFG. In the EPR program, producers can save the cost OTFG if the recycling rates are BG in both programs. The government increases recycling by raising the recycling rate to BG annually.

3.2. Recycling structure of metal packaging

The characteristics of the two programs are outlined in Table 1. Targeted producers in the WDR and EPR programs are those using metal packaging for their products. A key difference between the two programs is that the EPR program targets only producers who meet the following two criteria: (a) having more than 1.0 billion won in domestic sales or 300 million won of imports in the previous year, and (b) having more than 4 tons of domestic production shipments or 1 ton of imports in the previous year (GOK, 2011a). Producers that do not meet either criterion are exempted from the recycling duty.

Table 1. Characteristics of the WDR and EPR programs

	WDR program (1991–2002)	EPR program (2003–)
Costs	Producers	Producers above minimum

		production level
Regulatory measure	–	Recycling quota and fines for noncompliance
Economic instrument	Product charges and partial refunds transferred between producers and government	

The basic recycling scheme in both systems is collective recycling by a third party, namely, the Korea Metal Cans Resources Association (KMCRA, interview, July 5, 2013). Producers have contracted out recycling tasks of metal packaging to the KMCRA since 1994.

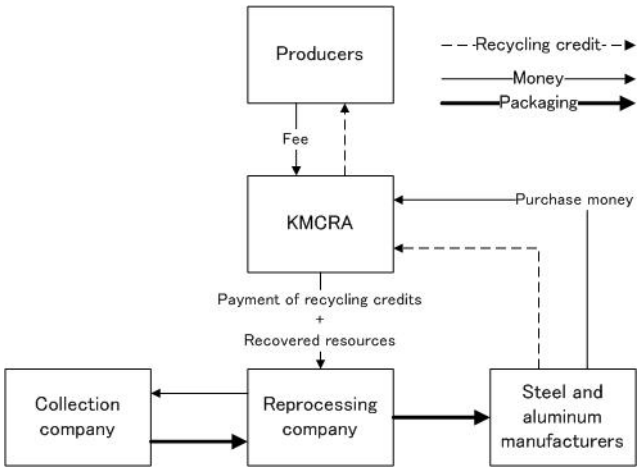

Fig. 2. Recycling operations of the KMCRA in the WDR and EPR programs
Source: Author compilation based on an interview with the KMCRA on July 5, 2013

The flows of money, recycling credits, and metal packaging are presented in Fig. 2. Producers who contract out recycling to the KMCRA pay a fee to the KMCRA. This fee is determined uniformly based on the size of production output. The KMCRA buys recycling credits from scrap metal reprocessing companies based on the report of steel and aluminum manufacturers. The contracted reprocessing companies make payments to procure the discarded metal packaging, and provide the scrap metal to steel and aluminum manufacturers as determined by the KMCRA. These manufacturers then report the weight of the scrap metal and collectively pay the KMCRA for the purchase of scrap metal. Then, the KMCRA passes on moneys from the sales to reprocessing companies, as well as to make payments for recycling credits. The price of recycling credits is financed by a producer fee. This price is annually determined by a committee composed of the KMCRA, reprocessing companies, producers, and experts (KMCRA, interview, July 5, 2013).

4 Materials and methods

4.1 Recycling rate

The WDR and EPR programs define recycling as the process of changing discarded metal

packaging into new metal products (GOK, 2002a; GOK, 2011b). One difference between the programs is that under the EPR program, it is possible to include the volume of exports for recycling when determining EPR recycling credits. However, in 2011, 90% of recycling under the EPR program was processed domestically through the KMCRA (KMCRA, 2012). For this reason, this paper disregards the possibility of recycling via exports and regards all recycling in the EPR program as being conducted in Korea only.

The recycling volume under the WDR program must be estimated because it is not available as a tonnage figure, while the amount of recycling in the EPR program can be derived from data from the MOE (2013). Due to limitations in the data, only the amount of recycling for the year 2000 was calculated. WDR recycling volume was estimated from the following: the refund total in 2000 was 9.7 billion won (8.6 million US dollars) (MOE, 2001); the refund amounts for steel and aluminum packaging were 46,000 and 111,000 won per ton, respectively (Chang et al., 1999); and the generation ratio of used steel and aluminum packaging was 95% and 5% by weight, respectively (Chang et al., 1999). Thus, the equations can be expressed as follows:

$$(x \text{ ton} \times 46 \text{ thousand won}) + (y \text{ ton} \times 111 \text{ thousand won}) = 9{,}679{,}963 \text{ thousand wons.} \quad (1)$$

$$x \text{ ton} = (x \text{ ton} + y \text{ ton}) \times 95\%, \quad (2)$$

where x stands for the amount of recovered steel packaging and y stands for the amount of recovered aluminum packaging.

In order to estimate the recycling rates, we must have a common denominator for the analyzed period. The shipment volumes of the targeted producers in the WDR and EPR programs are not appropriate as a common denominator because the range of producers is narrower in the EPR program than in WDR programs. The exemption standards for producers were introduced only with the start of the EPR program (GOK, 2002b). The most appropriate indicator is the amount of annual metal packaging consumed in South Korea. However, such data are not available. Instead, this paper uses data on the generation of metal packaging (MOE, 2012). It is noted that these data represent the amount of production for domestic steel and aluminum packaging, which excludes imported products.

4.2 Social costs and benefits of WDR and EPR programs

4.2.1 Social costs and benefits

To compare the costs and benefits of the WDR and the EPR programs, we estimate the costs and benefits of the recycling programs in the years 2000 and 2011. The year 2000 is the final year when the WDR program began to be phased out, and the year 2011 is the most recent year of available data under the current EPR program.

Table 2. CBA framework

Content

Cost	Producers	Administrative expenses of KMCRA Recycling credits of recyclers
	Recyclers	Collection, transport, and recycling of metal packaging
Benefit	Recyclers	Income from sales of recovered resources Recycling credits
	Society	Prevention of social costs that usually accompany landfill disposal (landfill disposal of incombustible wastes)

Table 2 shows our analytical framework, which is a modification of Smith's CBA framework and clarifies the incidence of costs and benefits. Costs consist of KMCRA administration, payment of recycling credits, and recycling costs incurred by reprocessing companies. Producers bear the costs of KMCRA administration and payment for recycling credits. The actual collection, transport, and recycling costs are counted as recyclers' costs. Benefits consist of revenues of reprocessing companies and savings of landfill space and disposal. Producer payments for recycling credits that are provided to reprocessing companies are included in the benefits to recyclers.

Studies by the Korea Environment Institute (KEI, 2002) and Choi et al. (2007) provide possible estimates of the cost per ton for collection and recycling. This paper uses the estimate in KEI (2002), as it is based on an actual area that was representative of dwelling patterns in Korea. KEI (2002) seems to come closer to actual cost compared to Choi et al. (2007), which assumed a uniform dwelling pattern.

In addition, the social benefits of recycling are estimated on the assumption that discarded metal packaging would otherwise be channeled to one disposal route, landfilling, if not recycled under the WDR or EPR program. The unit price for this calculation is based on the previous research by Mok (2005). To date, this is the only research that estimates the average cost related to landfill disposal at the national level in South Korea. The landfill disposal costs by Mok (2005) are composed of four components; land use for 50 years, and construction, operation, and post management for 15 years. The post management includes the costs of leachate and gaseous emissions. The estimated value by Mok (2005) is about 34% higher than the landfill tax for incombustible wastes in the capital area (CLC, 2013).

Smith (2005) counted the reduced external costs of landfill disposal and the saved production of virgin materials as social benefits of a recycling program. Regarding the former, the external cost components of landfill disposal are considered to be already covered by the data of Mok (2005). Regarding the latter, we use sales of recovered scrap metal as a substitute for saved production of virgin material. For the price of recovered scrap metal, we use the average market price of middle grade scrap metal materials during the past 5 years (2008–2012) based on statistics from the report Market Trend of Recovered Resources put out by the Korean Statistical Information Service (KOSIS, 2013c). The costs and benefits per ton used in our analysis are shown in Table 3.

Table 3. Costs and benefits per ton for recycling and landfill disposal

	Content	Material	Price/ton (Thousands of won)
Cost	Separate collection, sorting, storage	Steel	199
		Aluminum	1,005
	Transport	Steel	33
		Alum.	72
	treatment (compress and shred)	Steel	68
		Alum.	161
Benefit	Sales of recovered resource	Steel	254
		Aluminum	1,211
	Collection, transport, landfill	Incombustible	161

Source: KEI (2002), Mok (2005) and KOSIS (2013c)

As Table 3 shows, the transport and treatment costs per ton are higher for aluminum packaging than for steel packaging. Aluminum packaging is lighter than steel packaging of the same size. As a result, for a given weight of aluminum packaging, a volume of metal several times larger must be transported and treated compared with steel packaging.

To express the value of money on the same basis, we adjusted all relevant values to 2011 values by using the GDP deflator (KOSIS, 2013a). For the sake of international discussion some values are expressed in both won and US dollars by using the average US dollar–won exchange rate for 2011 (1 US dollar = 1,131 won) (KOSIS, 2013b).

4.2.2 Producers' costs

Producers' costs in the WDR program in the year 2000 (WC) can be calculated using the following equations:

$$WC = Deposit - Refund + Recycling\ cost, \quad (3)$$

$$Deposit = Refund / 83.4\%, \quad (4)$$

$$Refund = Q \times T, \quad (5)$$

$$Recycling\ cost = KMCRA\ administration + Payment\ of\ recycling\ credits, \quad (6)$$

$$KMCRA\ administration = Refund \times 17\%\ (Steel{:}Aluminum = 95\%{:}5\%), \text{ and} \quad (7)$$

$$Payment\ of\ recycling\ credits = Refund \times 73\%\ (Steel{:}Aluminum = 95\%{:}5\%), \quad (8)$$

where WC, Q, and T stand for producers' costs, recycling amount, and per ton refund in WDR program, respectively. Per ton refund (T) was 46,000 won for steel packaging and 111,000 won for aluminum packaging (Chang et al., 1999). The refund rate was 83.4% of the total amount of deposit

in 2000 (MOE, 2003). The recycling costs under the WDR program are mainly composed of two elements: the KMCRA administrative cost, and the payment of recycling credits to reprocessing companies. Of the total refund amount, 17% was spent on KMCRA administration and 73% on the payment of recycling credits (Chang et al., 1999). Based on this information, producers' costs in the year 2000 were estimated and then multiplied by 1.32 to adjust to 2011 values (KOSIS, 2013a).

The cost for producers in the EPR program (EC) is composed of KMCRA administrative cost and payment for recycling credits. They can be expressed as follows:

$$EC = P / 87\%, \quad (9)$$

$$P = PT \times R, \text{ and} \quad (10)$$

$$A = EC - P, \quad (11)$$

where EC, P, PT, R, and A stand for producers' costs, payment of recycling credits, per ton price of recycling credit, recycling amount, and administrative costs of the KMCRA, respectively. In 2011, around 87% of producers' costs were used for payment of recycling credits (KMCRA, 2012). The per ton prices of recycling credits (PT) for steel and aluminum packaging were 60,000 won and 110,000 won, respectively (KMCRA, interview, July 5, 2013). The recycling amount (R) was 97,132 tons for steel packaging and 42,490 tons for aluminum packaging (MOE, 2013). Administrative costs (A) are calculated by subtracting the payment of recycling credits (P) from the total costs of producers (EC). Administrative costs are around 2 billion won (KMCRA, interview, June 17, 2013)

5. Results

5.1 Recycling rate

The recycling amount of steel and aluminum packaging are estimated to be 186,721 tons and 9,827 tons respectively in 2000. Although limited data availability prevents calculation of the amount of recycling in other years, it can be safely assumed that recycling rates increased under the WDR program because the refund rate of deposits increased over time (MOE, 2003). The estimated percentage of recycling amount in generation of metal packaging waste (the recycling rates) is shown in Fig. 3.

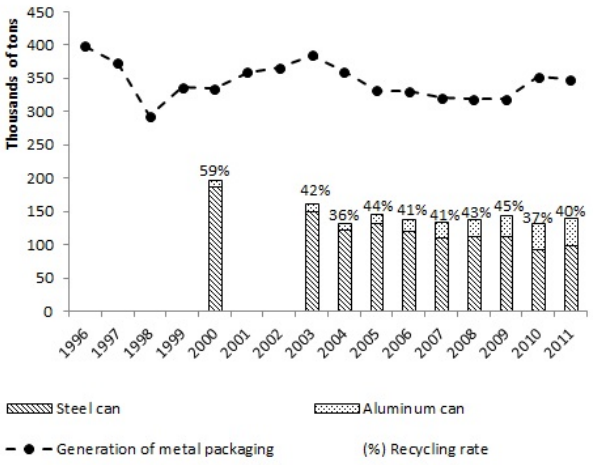

Fig. 3. The volume of metal packaging recycled by the WDR and EPR programs in the generation of metal packaging waste (2000–2011)
Source: Author compilation based on MOE (2012, 2013)

A drastic decline in the generation of metal packaging in the year 1998 can be attributed to the Asian financial crisis. After 2003 another decline occurred, which was followed by a period of stagnation. This change can be attributed to the increasing preference for plastic packaging and light aluminum packaging in the market (KMCRA, 2009). In 2011, the generation ratio of discarded steel and aluminum packaging was 70% and 30%, respectively (MOE, 2013).

Since the EPR programs started, the recycling rates have stayed below 45% and have not exceeded the recycling rate achieved under the WDR program in the year 2000. The primary reason for this reduction is the exemption of small- and medium-size producers from mandatory recycling under the EPR program.

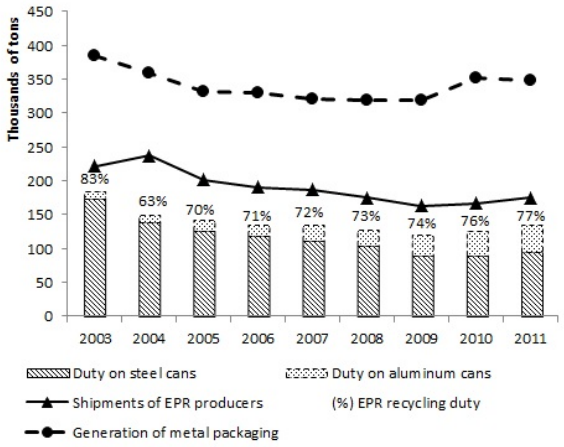

Fig. 4. The mandatory recycling volume in the shipment volume of EPR producers (2003-2011)
Source: Author compilation based on MOE (2012, 2013)

Fig. 4 shows that the volume of shipments from producers covered under the EPR accounts for only 50% of the overall generation of metal packaging in 2011. The percentage of the mandatory recycling volume in the shipment volume of EPR producers (the mandatory recycling rate) appears to have been increasing gradually since 2005. However, the actual mandatory recycling rate by definition is much lower than the mandatory recycling rate presented. This is because 77% of the mandatory recycling rate for EPR producers in the year 2011 corresponds to only 39% of the total generation of metal packaging. The 39% is far below the previous level of 59% that the government required producers to achieve in the year 2000 under the WDR program.

5.2 Social costs and benefits of the WDR and EPR programs

The results of the cost-benefit analysis in 2000 and 2011 are shown in Table 4. Limited data availability prevents estimates of cost-benefits in other years. The net social benefit of both programs is positive. However, our analysis also reveals that the net social benefit in 2011 is smaller than in 2000. This comes mainly from a decrease in recycling amounts, which led to the reduction in benefits from increased use of landfill disposal.

Table 4. Social costs and benefits matrix of metal packaging recycling in 2000 and 2011 (billions of won)

		Incidence	Content	2000	2011
Cost		Producers	Total	14.0	12.1 – 12.5
			(Steel)	13.1	6.7
			(Aluminum)	0.9	5.4
			KMCRA administration	2.2	1.6 – 2.0
			Recycling credit	9.3	10.5
			Unreturned deposit	2.5	–
		Recyclers	Collection and recycling	68.1	81.7
	Subtotal			82.1	93.8 – 94.2
Benefit		Recyclers	Total	68.6	86.6
			recovered resource	59.3	76.1
			Recycling credit	9.3	10.5
		Society	Landfill of incombustible wastes	31.6	22.5
			Unreturned deposit	0 – 2.5	–

Subtotal	100.2 – 102.7	109.1
Net benefit	18.1 – 20.6	14.9 – 15.3

Producers' costs totaled 14.0 billion won (12.4 million US dollars) in 2000 and 12.1 – 12.5 billion won (10.7 – 11.1 million US dollars) in 2011. Producers' costs decreased by 1.9 billion won (1.7 million US dollars) from 2000 to 2011 at a maximum. The policy shift from the WDR program to the EPR program allowed producers to save 2.5 billion won (2.2 million US dollars) in the "unreturned deposit" component. However, due to an increase in the payment of recycling credits and a decrease in the administrative costs of the KMCRA, producers ultimately saved 1.9 billion won in practice at a maximum.

Producers' costs for steel packaging in 2011 amounts to only half of the costs compared to 2000. By contrast, for aluminum packaging costs for producers in 2011 increased six times compared with the 2000 level. This result reflects the change in the amount of recycling for steel and aluminum packaging between 2000 and 2011.

Despite the decrease in the amount of recycling in 2011, the overall cost for recyclers increased, reflecting the higher average cost of collection and reprocessing of aluminum packaging. The recent increase in the consumption of aluminum packaging results in higher costs for recyclers as well. In the meantime, this enables them to earn higher revenue, because the higher price of recycled aluminum packaging brings higher economic profits. Because of this, benefits to recyclers in 2011 exceeded the benefits in 2000 by 18 billion won (16 million US dollars) in total.

Benefits to society are estimated at 31.6 billion (27.9 million US dollars) and 22.5 billion won (19.9 million US dollars) in 2000 and 2011, respectively, a decrease of 9.1 billion won (8.0 million US dollars) over that period. This decrease results from the smaller cost savings of landfill disposal.

The net benefits of the programs are estimated at 18.1 billion won (16.0 million US dollars) in 2000. If we assume that the government spent 2.5 billion won of "unreturned deposit" on the establishment of recycling infrastructure in 2000, the net benefits in the year 2000 are within a range of 18.1 – 20.6 billion won (16.0 – 18.2 million US dollars). The net benefits in 2011 are within a range of 14.9 – 15.3 billion won (13.2 – 13.5 million US dollars).

6. Discussion

The WDR program was replaced with the EPR program with the aim to increase recycling rates by increasing the economic responsibility of producers. However, our estimation clarified that the recycling rate of metal packaging dropped from 59% in 2000 to 40% in 2011, and recycling volume dropped accordingly. Despite the decrease in total recycling volume and rate in 2011, producers' cost of recycling credits increased than that in 2000. This is because of the increased recycling volume and the higher unit price of recycling credit for aluminum packaging compared with steel packaging. Our estimation suggests that since the EPR program began, the recycling

volume and rate of metal packaging have decreased, due to the increased cost burden of producers accrued from aluminum packaging. In addition producers that use aluminum packaging now face a higher cost burden under the EPR program than under the WDR programs because small- and medium-size producers are exempted from the mandatory recycling requirement. In order to set an ambitious recycling target, it is necessary to mitigate this unequal treatment.

Also worth noting is that this research does not cover the environmental assessment because of the lack of data for defining the environmental impacts of the WDR and EPR programs in monetary terms in Korea. Craighill and Powell (1996), Vigsø (2004), and Lavee (2010) showed in their environmental assessments that among various types of packaging, aluminum packaging brought the highest net benefits from recycling. This is because of the enormous amount of electricity required to convert bauxite into aluminum ingot and thus able to be saved by using recovered aluminum in the production stage. It is a future challenge to make an integrated financial and environmental assessment of the WDR and EPR programs.

7. Conclusion

The Korean government replaced the WDR program with the EPR program in 2003. The original purposes of this policy change were the reduction of waste and the minimization of costs.

Regarding the recycling rate, we found that recycling rate has not exceeded the rate from the year 2000. This paper estimates that the rate dropped from 59% in 2000 to 40% in 2011 and recycling volume dropped accordingly. This decrease implies that municipalities and society have to bear increasing external costs associated with landfill disposal, although data constraints preclude an investigation of the size of this increase.

Cost-benefit incidence analysis shows that net social benefits decreased by 2.8 billion won (2.5 million US dollars) at a minimum, while the net benefits to producers increased by 1.9 billion won (1.7 million US dollars) at a maximum under the EPR program compared with the WDR program. These changes in costs and benefits mainly resulted from a decrease in the amount of recycling, which ultimately increased costs for landfill disposal.

As theoretical explanations suggest, the EPR program can achieve a higher recycling rate and greater net social benefits. To realize such improvements, the government of South Korea should tighten program standards and narrow the scope of the exemption given to small- and medium-size producers.

Acknowledgements

This research was supported by a FY2013 Graduate School of Global Environmental Studies Research Grant for Young Faculty and Doctoral Students. The funding source played no role in the design, execution, or reporting of this study.

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