Government Mandated Resource Circulation for Recycling Metal Cans in South Korea

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Abstract

South Korea has developed its economy based on strong manufacturing industry. Decreasing global natural resources and the global movement toward sustainable growth, however, might limit the country's development in the future. While the country's strength is in transportation and electrical products, South Korea relies mostly on imports for its mineral needs, such as iron ores. At the same time, the recycling rate for metals has been relatively low compared with the rate for other materials. With the new President Park, Geun Hye, the new government started focusing on building a society that promotes circulation of resources through the proposed Act on Promotion of Transition to Resource Circulation Society. This study examines how the government-mandated resource circulation should work, and recommends a practical solution to improve the recycling of metal cans.

This study briefly explains the development of Korean economy since 1950s and the growing focus on sustainable development, and also examines the structure of the metal can production process. This is followed by a review of Chinese circular economy and how it outlines the national effort to promote the circulation of resources. The analysis concludes with a case study of reverse vending machines, which the government may be able to implement in a mandated basis by the law or action plans. Recommendations for the country to move forward, and a discussion of further actions need in South Korea are then provided. This study recommends the engagement of the three major stakeholders in the resource circulation society and five important criteria for a successful mandated recycling program. These recommendations will contribute to further the knowledge on industrial ecology and how a country may mandate a recycling program in a large scale.

Acknowledgments

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Introduction

After the Japanese colonization period from 1910 to 1945, and the Korean War from 1950 to 1953, Korea was in a devastating state. Indeed, an American journalist after the War said Korea was "a land of misery and chaos, and a nation unable to help itself because it has no voice in any major decision affecting its future" (Kim, 1). These two historic tragedies caused the Korean economy to have a per income capita on level with the poorest countries on Earth. At that time, Korea did not have an advanced infrastructure, with most buildings and factories destroyed by the end of the War. With minimal industrial infrastructures, the country's economy was heavily based on agriculture. However, after the launching of the First Five-Year plan in 1962 by the government, South Korea changed its focus from agriculture to manufacturing. That structural transformation has become a major contributing factor for the country to enjoy the rapid growth since 1960s. Between 1961 and 1981, Korea "has achieved remarkable economic and social progress … [which] was accompanied by structural transformation from subsistence agriculture to modern manufacturing" (Kim, 3). So far, the Korean economy was "driven in part by the development of an export-oriented manufacturing sector" (Cusbert et al., 7), with the manufacturing share of GDP around 30%. Figure 1 shows that the country has been consistently focusing on the development of the manufacturing industry to promote

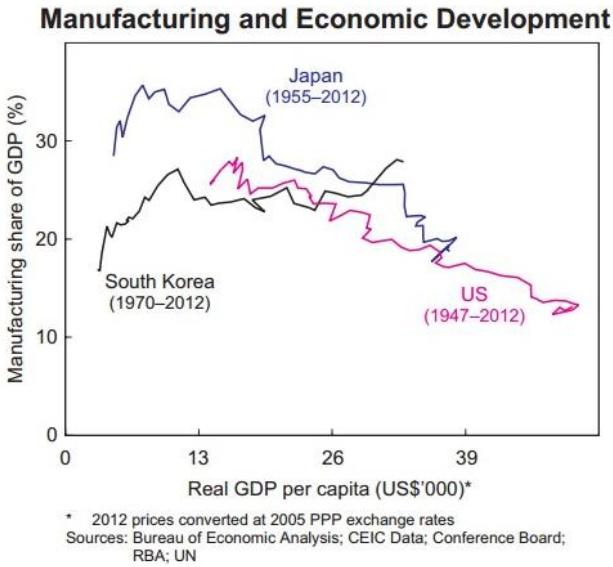

Figure 1. Manufacturing Share and Real GDP per capita growth of South Korea from 1970 to 2012 (Cusbert et al., 8).

the growth of the national GDP since 1970. The focus of manufacturing in 1970s and 1980s was on textiles, leather, food and beverages. However, now the country's manufacturing industry is focusing on electrical and electronic equipment, metal products and transportation (such as shipbuilding and automobile industry). Indeed, the transition to focus on manufacturing is successful up until now. For example, according to Cusbert et al., Korea has the fifth largest automobile industry in the world, and is one of the global leaders in the shipbuilding industry.

While this transition and focus contributed significantly to the economic growth of the country, there are also drawbacks with this approach. Mineral resources in South Korea are meagre, and all of the country's crude petroleum requirements and most of its metallic mineral needs (including iron ore) are met by imports, according to the Britannica encyclopedia. This takes much of the power over the economy out of the country and the industry leaders, since they have to rely on imports from other countries for raw materials. This also means the suppliers, who are exporters of metallic mineral and law materials, are able to exercise power over the manufacturing firms in South Korea. From Figure 2, it is possible to observe that the imports of iron ore and concentrates have been increasing much since 2000. When natural resources were relevantly abundant, the costs to import them were relatively small.

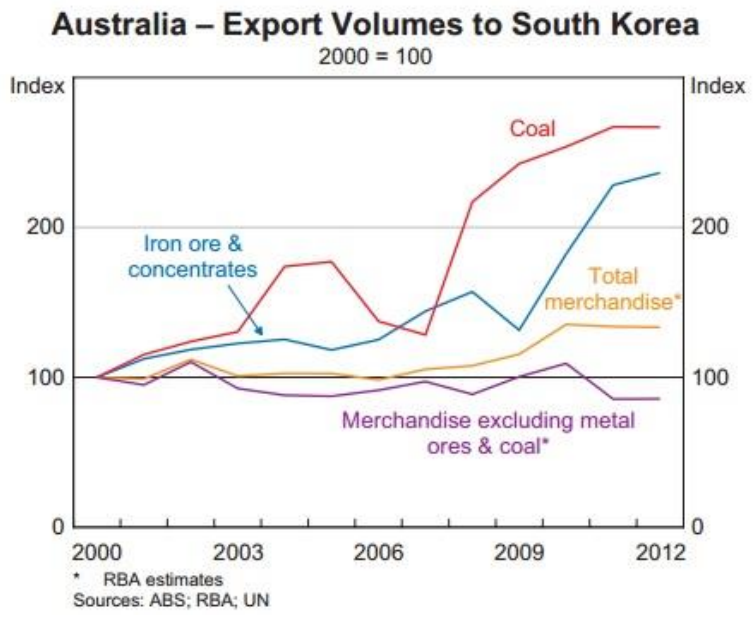

Figure 2. Export Volume to South Korea from Australia since 2000 (Cusbert et al., 12).

However, with the rise of manufacturing industries in developing countries such as China and India, South Korea is facing an environment where the amount, cost and the value the natural resources become much more significant than the time when the country started to develop the manufacturing industry. An example from the rare earth materials case shows how a country can control the flow of the raw materials. Raw earth materials are "the salt of life for the hi-tech revolution, used in iPads, plasma TVs, lasers, and catalytic converters for car engines" (Evans-Pritchard). Demands for those materials have increased dramatically as they are crucial to produce hi-tech related products, and even advanced weapons such as tanks and missiles. For the rare earth materials, China "has a near total monopoly in the heavier end of the spectrum, though it is also the dominant supplier of the whole rare earth complex after driving rivals out of business in the 1990s. It still accounts for 97[%] of global supply" (Evans-Pritchard). As China started to restrict supplies, other countries such as Japan and the United States have struggled to find other ways to find the rare earth materials, which requires much investment of time and effort to do so. The world of cheap and readily accessible natural resources is about to come to an end. We are living in a world where natural resources can become an effective tool, or sometimes weapon against other countries to prevent further growth.

Another factor to consider is the increasing focus on environmentally sustainable growth among the developed countries. According to an e-book on Korea's Green Growth published in 2012, "the concept of green growth starts with the introduction of sustainable development. The 1972 book "The Limits to Growth" published by the Club of Rome reports that the world would face the limits to growth within a century" (Statistics Korea, 3). However, the concept of sustainable development has not been a popular agenda in the mid-20th century. It was out of favor among many firms and governments "due to cheap and abundant energy, resources, and

disposal options, subsidies that discouraged recycling, and regulations preventing reuse" (Lombardi et al., 2). Now, they are facing "increasing waste disposal costs, concerns over environmental degradation accompanied by stricter environmental regulations, and a growing awareness of the potential profits from by-product and waste utilization" (Lombardi et al., 2). It was not until very recent times that the sustainable development agenda re-gained popularity which led firms, countries and governments to start looking into ways to ensure that the economy grows without harming the environment much, and that their developments are sustainable. They start to realize that industries and environments cannot be separated; rather, they not only care about the main products they produce, but also grow concerns on how they are going to manage the non-product outputs, such as by-products and wastes.

South Korean government starts to be aware of these trends and issues. In the e-book on the green growth, it is stated that "the necessity for environmentally-friendly economic growth is emerging due to a deepening global environmental crisis and depletion of natural resources" (Statistics Korea, preface). Even before this e-book was published before 2012, there were several national-level efforts to incorporate the concept of sustainable development while pursuing an economic development. For example, as part of its Green Growth strategy, South Korea started the first phase of the National Plan for Eco-Industrial Park Development in 2005 to develop resource cycling in existing industrial parks in a metropolitan city called Ulsan, where many manufacturing firms and factories are located. These Eco-Industrial Parks were built to "conserve natural and economic resources; reduce production, material, energy, insurance, and treatment costs and liabilities; improve operating efficiency, quality, worker health, and public image; and provide opportunities for income generation from the use and sale of waste materials" (Park et al., 11). The city originally suffered severe damages from environmental pollution until

1980s. To rectify the situation, the government imposed stricter environmental standards and regulation, which led "enterprises [to intensify] their investment in pollution prevention and environmental management" (Park et al., 11). Then in 2007, the country made another bold movement to impose a regulation to promote sustainable development by adopting the Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles. The Act, which was passed by the National Assembly of South Korea, puts regulations on electrical equipment and automobiles. According to RSJ Technical Consulting, the Act includes five major requirements for producers and importers, which are the following below.

- Restrictions on the use of hazardous materials
- Improvement of materials and structure in products
- Allocation of mandatory recycling rate
- Development of recycling information network
- Designation of collection places for waste products

This Act, which was similar to the Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) of the European Union in some aspects, was another effort by the Korean government to mandate the recycling and promote the circulation of resources. While this Act was another big step, it was limited because it was focused mostly on the electricity-based products.

In February 2013, as the new President came to the office, the new government decided to develop the effort by the previous times further, to promote the transition to resource-circulation society. There has been series of discussions, and the new President and government officials visited various recycling facilities and highlighted the significances to decrease the amount of wastes and promote recycling. In other words, if this Act would be in place, it would

become the basis of the government-mandated resource management and recycling efforts. With much deliberations and thoughts, the Act titled "Act on Promotion of Transition to Resource-Circulation Society" was proposed by a member of National Assembly Choi, Bong Hong in July 2013, to establish "a solid foundation to realize resource-circulating society" (Ministry of Environment), and to provide "wide-ranging policies such as implementing a target management system on resource circulation, imposing a charge on reclamation, expanding use of recycled resource, and so forth" (Ministry of Environment). The Act was expected to build a society of resource circulation that minimizes generation of wastes and reduces consumption of natural resources and energy by efficiently utilizing resources from production to distribution and consumption. The proposed Act went through public hearings in August 2013 to hear opinions of various stakeholders, such as people from industry, academia, civil organizations and the government. After the public hearing, the draft of the Act was submitted in September, 2013. Currently, it is announced to be enacted, while the exact date as to when the Act will have the legal authority is yet to be identified. The next section discusses the background information on the recycling status of the metal cans, the structure of the metal can production and recycling process, and the details of the draft of the Act on Promotion of Transition to Resource-Circulation Society to provide more details on why the metal cans were selected among many different resources for this study.

Background

There are many different materials which can be recycled (e.g., paper, scrap iron, metal cans, glass, and tire (rubber)). Among these wastes, this research focuses on metal cans, because they have been recorded to have the lowest recycling rate. It should be taken into account that the amounts of the waste generated are different among different resources. The tables and figures below show how the numbers are different. The data tables and figure are both in Korean and English. They are translated for this paper if there is only Korean explanation.

6. 폐기물 재활용 현황

Waste Recycling

(단위 : 천톤 / 년, %) (Unit : 1,000ton / year, %)

Category				2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
폐지 (천톤) Paper (1,000 Ton)	Amount of Paper Produced			10,660	10,999	11,182	11,279	11,244	11,602	11,253	10,759	11,473	11,526
	Amount of Paper Consumed (A)			9,339	9,965	9,909	9,868	9,889	9,893	9,486	8,727	9,548	9,338
	Raw Material Use	Total		10,540	10,897	11,479	11,436	11,599	12,275	12,057	11,556	12,956	13,000
		Pulp		2,943	2,955	3,082	2,935	2,932	3,129	2,944	2,622	2,771	2,738
		Waste paper	Sub-Total	7,597	7,942	8,397	8,501	8,667	9,146	9,113	8,934	10,185	10,262
			Domestic (B)	5,999	6,611	6,875	7,086	7,455	7,998	7,902	7,851	8,857	8,827
			Imported	1,598	1,331	1,522	1,415	1,212	1,148	1,211	1,083	1,328	1,435
	Domestic Rate of Use of Waste Paper (B/A)			64.2	66.3	69.4	71.8	75.4	80.8	83.3	89.9	92.7	94.5

Figure 3. Waste Recycling Data for Paper from 2002 to 2012
(Ministry of Environment. "2012 Environmental Statistics Yearbook.")

고철 (천톤) Scrap Iron (1,000 Ton)	Amount of Iron Used		43,720	45,370	47,218	47,124	48,299	55,108	49,969	48,123	55,906	68,519
	Use of Scrap Iron	Total	23,773	23,394	25,923	25,641	24,268	29,600	24,833	26,270	22,400	24,666
		Domestic (B)	16,550	17,160	18,375	18,825	18,490	22,716	18,022	19,230	16,134	18,324
		Imported	7,223	6,234	7,548	6,816	5,778	6,884	6,811	7,040	6,276	6,342
	Domestic Rate of Use of Scrap Iron (B/A)		37.9	37.8	38.9	39.9	38.3	41.2	36.0	40.0	28.9	26.7
금속캔 (천톤) Can (1,000 Ton)	Total Amount Generated		366	384	360	331	330	321	319	319	352	348
	Total Amount Recycled		168	195	159	146	159	195	205	160	138	176
	Rate of Recycling		45.9	50.8	44.2	44.1	48.2	60.7	64.3	50.2	39.2	50.0

* 자료 : 환경부 자원순환국 자원재활용과 Source : Ministry of Environment, Resource Recirculation Bureau

Figure 4. Waste Recycling Data for Scrap Iron and Metal Cans from 2002 to 2012 (Ministry of Environment. "2012 Environmental Statistics Yearbook.")

		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
폐유리 (천톤) Glass (1,000 Ton)	Total Use of Glass Bottles	794	756	760	776	749	731	703	641	660	716
	Total Use of Waste Glass	587	530	544	567	531	533	513	471	495	535
	Rate of Recycling (%)	73.9	70.1	71.6	73.0	70.1	72.9	73	73	75	75
폐타이어 (천개) Tire (1,000 Pieces)	Total Amount of Waste Tire	24,023	23,233	260,266	275,072	282,990	294,200	307,926	293,930	316,721	310,991
	Total Amount of Recycled Tire	17,167	18,561	190,477	212,997	223,085	227,131	227,946	223,561	236,903	234,861
	Rate of Recycling (%)	71.5	79.9	73.2	77.5	78.8	77.2	74.0	76.1	74.8	75.5

Figure 5. Waste Recycling Data for Glass, Glass Bottles and Tire from 2002 to 2012 (Ministry of Environment. "2012 Environmental Statistics Yearbook.")

Figure 3 shows that the recycling rate of paper (or the rate of use of waste paper) has been increasing since 2002, and reached above 90 percent in 2011. Figure 5 also shows that the recycling rate of both waste glass and tire (rubber) has been fairly stable, around mid-seventy percent. The problem lies in the metals (Figure 4). As discussed in the Introduction, uses of metals (especially iron) have been large, with 68 million tons of total iron used in 2011. While the use of iron has been increasing, the use of scrap iron has not been changing much, which led to the decreasing rate of recycling. Meanwhile, the use of metal cans have been remaining stable since 2002, and the total amount of recycled metal cans also have remained stable. The data in Figure 4 shows that the recycling rate has not exceeded more than 60 percent. Since there are various sources and uses of scrap irons to identify, the study focuses on metal cans, which are identified as one of the two resources which the waste resource management has remained poor compared to other resources and wastes in terms of recycling rate. Uses of metal cans are also easier to identify, since they are one of the things that many people use. In general, they are used for distributing or storing goods, such as food (corn, beans), beverages (beer, soda), or sometimes even chemical products (chemicals, petroleum).

The Korean government has been aware of the trend that the recycling rate of the metal cans have remained lower than other wastes and/or resources. For example, the 1st Base Plan for Resource Circulation (2011-2015) was published in September 2011 to shape the environment and foundation for green growths and upcycling of waste resources. The Plan stated that the problem came from the fact that while there were firms in operation to collect and process the waste metal cans, there were no metal cans manufacturers which had the system to collect and process the waste metal cans for recycling. The Plan also provided broad strategic plans to promote recycling, future tasks to move forward, economic analysis, goals on recycling rate

improvement, and potential index. However, the Plan did not provide many details specifically on the metal cans and the ways to improve the recycling rate. The only potential solution provided was to add and install automated collection systems in various locations, such as department stores and malls where many people gather around to collect metal cans. In 2013, the Draft of the Act on Promotion of Transition to Resource-Circulation Society also included some analysis on the recycling of the metal cans. The Draft of the Act also included "the Analysis of the Effects from Potential Regulations." Here it included that while firms should utilize the recycled products and resources from the recycling firms, firms still had concerns about the quality, and sometimes they even considered that the recycled products and resources had low quality as wastes. Therefore, what the Act proposed was to make the use of recycled resources mandatory for the designated firms, with the set usage goal based on the percentage. For the metal cans, the Act proposed to designate and impose the steel and steel manufacturing industry to use at least 65% of the recycled resources from the waste metal cans, with no alternatives to this potential regulation. To maximize the impact of this, it is essential bring the recycling rate of the metals and metal cans up as much as possible, which has been currently remaining around 50 to 60% at most. By increasing the recycling rate, more and more recycled metals are used by the manufacturing firms. The Act also proposed to mandate the use of recycled resources for waste paper and glasses, but the mandate for paper and glass was reasonable because the gap between the target rate of usage and the actual status was small. However, there existed a huge gap between the target rate of usage and the actual result. The table below shows how they the numbers are significantly different.

Resources for Recycling	Target Rate for Usage	Actual Rate of Usage (2011)
Paper	80%	76.5%
Glass	75%	74.7%
Scrap Iron and Metal Cans	65%	26.7%

Figure 6. Target Rate for Usage of Recycled Resources and the Actual Rate in 2011 (Ministry of Environment. "The Analysis of the Effects from Potential Regulations.")

From Figure 6 above, it is possible to verify that while the target rate of usage for the scrap iron and metal cans is high, the actual rate of usage is much lower than the expected level. Meanwhile, the target rate and the actual rate for paper and glass are close to each other, implying that it is likely to reach those goals in a near future with not too much effort. A cost-benefit analysis is also provided on the potential mandate to impose the steel and steel manufacturing industry to use at least 65% of the recycled resources from the waste metal cans. It is stated that the mandate would promote the creation of additional jobs, the development of related technology, the decrease of the production cost and social externalities (such as greenhouse gas emissions). A problem from these statements is that there were no quantitative calculations or data to support. The Analysis also states that there would be minimum interference on the market and its players (firms) as the mandate would designate firms to use the recycled resources.

One effective method to increase the amount of recycled metals is to increase the recycling rate of the metals, and for this study the focus is on metal cans. This way, the circulation of resources is becoming possible, as both supply (recycled metals) and demand (manufacturing firms) are met. The Act recognizes that about 56% of the recyclable wastes were simply buried or incinerated as of 2011. Since those two methods (burying or incinerating) cost less than recycling, recycling is less preferred from the business perspective. What the Act

proposes to promote the recycling is to charge the firms which bury and/or incinerate wastes. Therefore, so far, the Act proposes two ways to promote the recycling, which are to mandate the use of recycled metals and to charge firms which do not do recycling.

At this early stage it may be appropriate for the Act and the Analysis to provide large, broad pictures and strategies to promote the transition to the resource-circulation society; however, several issues will need to be addressed. First, it is uncertain whether the mandate will be the best solution to promote the recycling rate of the metal cans. As stated in the 1st Base Plan, it might also be possible to look into the possibility of installing and spreading automated machines to collect metal cans to improve the rate. Second, it is uncertain whether the proposed benefits from the Act and Analysis would be realized. Some of the benefits were discussed in those aforementioned documents – economic benefits, technological benefits, environmental benefits and actual impact on the recycling rates. Therefore, this study focuses on attempting to answer the two main questions posed above before the Act is in official legal position and the subsidiary action plans and laws are developed subsequently. The next section, which is Methods and Experimental Design, explains in detail how the study examines potential solutions and options for the Korean government to adopt to improve the recycling rate of the metal cans, which will contribute to achieve the transition to the resource circulation society.

Methods and Experimental Design

This study focuses on providing recommendations for the upcoming Act on Promotion of Transition to Resource-Circulation Society. The analysis begins with a review of the general structure and cycle of the metal can industry, from acquiring the raw material to production, then production to recycling stage. The study then moves to a case study of the Chinese Circular Economy model in China where the country already enacted and promoted the government-led circulation of resources. By reviewing journals such as Journal of Industrial Ecology and Journal of Cleaner Production, the Law on Chinese Circular Economy and various media coverage, the study explores how Chinese government took initiatives to promote the transition to the circular economy, and how the policy guides to incorporate all the major stakeholders. Journals that were closely related to industrial ecology and recycling were chosen for this study. After reviewing Korean and Chinese laws on promoting the resource circulation, this study defines the five major criteria for the recommended methods to promote recycling rates of the metal cans to succeed. Then, the next part and focuses on a potential recommendation for the Korean government to implement, the reverse vending machine. The feasibility of the implementation of this machine and mandate its use is analyzed by considering five criteria suggested which include economic, technological and environmental benefits, actual impact on the recycling rate and engagement possibility of major stakeholders. The feasibility study is conducted by reviewing journals such as Journal of Industrial Ecology, online resources from global firms which already established businesses from the reverse vending machines. The study is concluded by discussions, potential implications and possible limitations on the recommendation this paper proposes.

Results

Primary Questions:

- Is it possible to achieve a higher recycling rate for metal cans and promote the transition to the resource circulation society with the government-mandated Act to require firms to use certain percentage of recycled metals or to charge those who do not recycle?
- Are there alternatives to the mandate above, which is proposed as a solution to increase the recycling rate of the metal cans?

It is essential before considering these questions to look into the whole process of the industrial cycle of the metal cans from acquiring the raw materials to production, then production to recycling to become familiar with the potential recommendations provided in the latter part of this section. Metal cans are generally made of various metals, such as aluminum (or aluminum), tin and steel. The focus of this study is aluminum cans due to several reasons. According to the Canmaker, all drinks cans produced in the U.S. market are made of aluminum. Moreover, approximately "475 billion [metal cans are produced] for food, drinks, industrial products and aerosols" (The Canmaker) each year, "with the proportion of tinplate and aluminum cans being about 25/75 percent in 2009" (The Canmaker). The research report on the metal packaging in South Korea also shows that "retail unit volume of metal packaging increases by 5% to reach 5.5 billion units in 2012" (Euromonitor International, 1), and about 86 percent of them are metal beverage cans. The report also states that "it is difficult to estimate the share of major players in the metal packaging industry, as most companies have different product portfolios in the metal packaging industry" (Euromonitor International, 2). However, based on the analysis of the major metal packaging companies in 2011, it is possible to verify that most of them are focusing on

producing metal cans made of aluminum. The table on the next page shows the major metal packaging companies in South Korea and the ranking in 2011.

Company name	Ranking
Hanil Can Co Ltd	1
Lotte Aluminium Co Ltd	1
Techpack Solution Co Ltd	1
Sam Kwang Glass Co Ltd	1
Daeryuk Can Co Ltd	4

Figure 7. Ranking of Major Metal Packaging Companies in South Korea in 2011 (Figure from Euromonitor International, 3)

Among the firms above, Hanil Can Co Ltd, Lotte Aluminium Co Ltd and Techpack Solution Co Ltd are some of the leading firms in producing metal cans in aluminum. Hanil supplies "2-piece cans, 3-piece cans and aluminium can ends (stay-on tab) for soft drinks and beer" (Euromonitor International, 2), and Techpack supplies "2-piece aluminium cans mainly for beer and soft drinks" (Euromonitor International, 2). For the ease of understanding, 2-piece cans mean the bottom and body of the cans are drawn and ironed from aluminum-based flat plate or shallow cup. After the cans are filled up, the end of the can is sealed onto the top of the can. 3-piece cans are similar to the 2-piece ones except that they result in both top and bottom rims.

With those data in mind, the next part of this study is to explain the life cycle of the aluminum cans. Before explaining in detail, the figure below shows a simplified diagram of the lifecycle of the aluminum products.

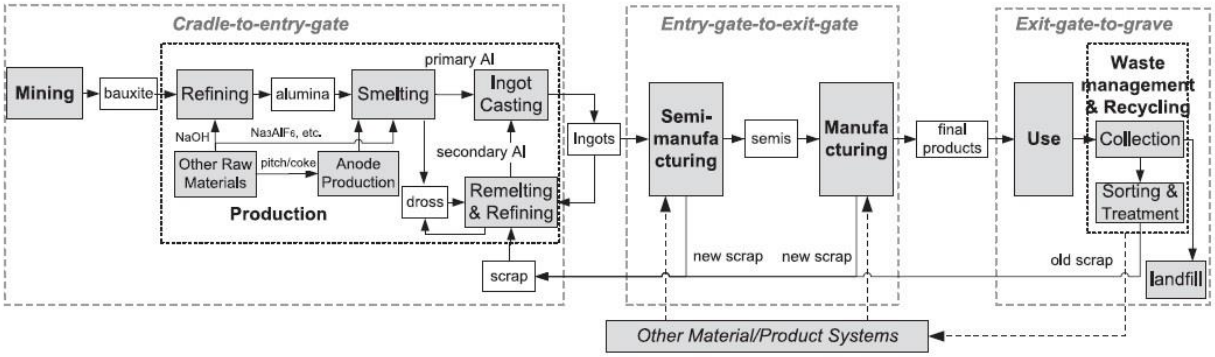

Figure 8. A diagram of the life cycle of an aluminum product system, from mining to recycling (Liu and Müller, 109)

Since this study's focus is on the recycling of the metal cans, the focus should be on the waste management and recycling of an aluminum product based on the figures in the previous page. The structure or system is established in a way that after an aluminum product (in this case, an aluminum can) has been used by consumers, it is collected by various ways. After aluminum cans are collected, they are sorted to either to generate recycled aluminum or to become landfill waste. From Figure 8, it is possible to observe that there is a circular process from sorting & treatment to other material/product systems, then other material/product systems to manufacturing process. This positive, virtuous cycle is what the transition to resource-circulation society aims to achieve. By doing so, manufacturers may rely less on raw materials produced from metal ores, and use more raw materials that are processed and collected from waste metal cans (in this case, aluminum cans). There are benefits as well, that "recycling of aluminum from scrap requires about 20 times less energy than primary production" (Liu and Müller, 110). However, some challenges exist as well. For example, the sorting and identification of scrap "become more difficult as the scrap arises closer to the final product stage" (Liu and Müller, 109). While new scrap generated at various production and fabrication stages possesses known quality and composition, and recycling is taking place extensively and efficiently, "the rate at which old scrap is recycled varies depending on societal commitment and processing technologies available

for different product categories" (Liu and Müller, 109). Moreover, there are some fundamental issues in recycling the aluminum cans. For example, the quality of the recycled aluminum may become lower during recycling depending on cost, plant, and product specific requirements, although "it is metallurgically possible to maintain the same properties" (Liu and Müller, 110). It indicates that some of the firms' concerns introduced in the Act, which one of the main concerns on quality, must not be overlooked when promoting the recycling rate of the metal cans, especially for the aluminum cans which are the majority of the metal cans produced. The figure below shows how the quality of recycled aluminum changes during the recycling process, which supports that the quality of recycled metals is an important issue to be resolved.

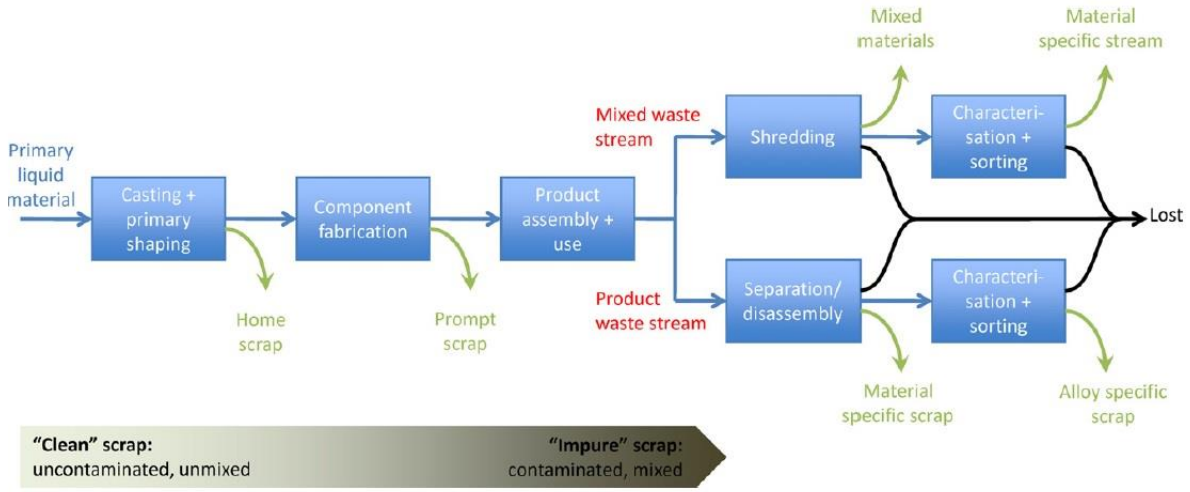

Figure 9. Recycling streams of aluminum products and the change of quality in each step (Allwood et al., 367)

Besides the concerns addressed on the quality, there are other barriers to increase the recycling rates of the metal cans. The Act suggested that by mandating firms to use certain fixed percentage of the recycled metals and by charging those who bury or incinerate wastes, there will be various benefits – economic benefits, technological benefits, environmental benefits and actual impact on the recycling rates. Again, to maximize the impact of the mandate, there must

be more recycled raw materials to feed the manufacturing firms so that firms use as much recycled metals as possible. To do so, the recycling rate of the metals and metal cans must be increased. Based on some of the government publications, there are not that many suggested solutions to increase the recycling rates to maximize the impact of the mandate. It is true that except for few products such as cement, recycling takes much less energy than primary production of goods. However, according to Allwood et al., "increasing recycling rates raise technical, economic and operational challenges" (Allwood et al., 366), as "streams of material available for recycling become increasingly impure as they move further along the materials processing chain, and therefore refining the stream for future high quality use becomes more difficult" (Allwood et al., 366). In order to promote the circulation of resources, not only the manufacturing firms have to use more recycled resources, but also recycling firms should produce more recycled metals for the manufacturing firms to utilize those metals (Figure 8). Allwood et al., present that technical, economic and operational challenges should be addressed to ensure that the recycling rates increase, in this case the recycling rate of the metal cans. Therefore, those challenges must be tested to see which options satisfy them to increase the recycling rate of the metal cans.

To find the alternatives to the two proposed methods to promote and improve the recycling rates, it might be beneficial to look into other countries where a government mandates the circulation of resources. Among many countries, the People's Republic of China (or China) is a country where it recently adopted the concept of circular economy, which incorporates increasing resources utilization rate, protecting and improving environment and realizing sustained development. The Law, known as "The Circular Economy Promotion Law" has been passed in the 4th meeting of the Standing Committee of the 11th National People's Congress on

Aug 29, 2008, and was entered into force as of January 1, 2009. While the Law does not provide specific action plans, or detailed guidance on the recycling of the metal cans, there are some interesting Articles to provide guidance on selecting potentially successful methods to promote and increase the recycling rate of the metal cans, which will eventually contribute to the society of resource circulation. In the Article 2 of the Law, the Circular Economy is defined as the general term "for the activities of decrement, recycling and resource recovery in production, circulation and consumption" (Hu, 1). The Law also provides separate and distinctive responsibilities for different stakeholders to ensure that each party is actively engaged in promoting the circular economy. This is different from the Act in South Korea, which tends to encourage participation of some but not all related parties, such as charging firms fines for poor waste treatments or burdening firms with set goals to use recycled or reclaimed metals. The three major stakeholders in the resource circulation society are government, firms and individuals. Chinese Circulation Economy Promotion Law provides guidance for all the three stakeholders. Articles below from the Law are as follows:

- Article 5: The general administration for promoting circular economy under the State Council shall be responsible for organizing, coordinating and regulating national circular economy promotion works
- Article 7: The State encourages and supports the research, development and promotion of science and technology regarding circular economy, as well as the publicity, education and popularization of scientific knowledge of and international cooperation on circular economy
- Article 9: Enterprises and institutions shall establish a sound management system and

take measures to reduce resource consumption and the generation and discharge of wastes, and improve their recycling and resource recovery level

- Article 10: Citizens shall have a better sense of resource saving and environmental protection, consume reasonably and save resources. The State encourages and guides citizens to use products and recycle products featured by energy saving, water saving, material saving and environmental protection, and reduce the generation and discharge of wastes. Citizens are entitled to reporting activities of wasting resources and destroying environment, to accessing official information on circular economy promotion, and to giving opinions and suggestions.

(Articles from Circular Economy Promotion Law of the People's Republic of China)

According to the Articles of the Law, the Chinese government is responsible for organizing and coordinating plans, and regulating individuals and firms. Firms have responsibility to establish a management system in harmony of the concept of the circular economy. Individuals also bear the responsibility to actively engage in saving and consume resources in a reasonable manner, and recycle products. Indeed, the overarching goal of the Circular Economy Law is much larger than improving the recycling rate of a specific product. There are three layers to implement the concept of Circular Economy. First layer is to ensure that "companies are either required or encouraged to conduct CP auditing" (Yuan et al., 6). Then, the second layer is "to develop an eco-industrial network that will benefit both regional production systems and environmental protection" (Yuan et al., 6). The last layer is "the development of the eco-city, eco-municipality, or ecoprovince" (Yuan et al., 6). However, the important concept to adopt and implement in selecting the appropriate methods to improve the recycling rate of the

metal cans from the Chinese Circular Economy Law is that the government should not mandate only some of the stakeholders to take on the whole burden. Rather, the mandate should be structured in ways that encourage active participation of all the stakeholders, which are again the government, firms and individuals. The criteria for the Korean government to adopt ways to implement and mandate ways to improve the recycling rate are the following: economic, technological, environmental benefits, actual impact on the recycling rates and active participation and engagement of all the three major stakeholders.

With these criteria in mind, one potential solution is the reverse vending machine (RVM). The vending machine is a familiar concept to most people-- a customer pays money either by cash or credit card to the machine in return for various types of consumer products such as snacks, beverages or cigarettes. It is an automated process. The reverse vending machine, however, has the opposite mechanism of the typical vending machine, taking used or empty beverage containers, and returning money to the customer. This concept was briefly introduced in the 1st Base Plan for Resource Circulation, but since the 1st Base Plan did not provide much details and feasibility of this option, we investigate this recommendation to evaluate whether it is possible to adopt those machines in South Korea. The concept of the RVM is not a new concept, since the first patent of this concept dates back all the way to 1920, and some countries are already using them to collect metal cans. Briefly introducing the history of the RVM, the first patent application was filed in the United States in September 13, 1920 by Elmer Jones and Sue V. Walker. In their patent application and description, the two authors stated that it was designed as a "receptacle for receiving the empty bottle or container, together with a mechanism for issuing a coin in return" (Jones and Walker, 1). They were hoping to achieve the objective, which was to "provide a construction which permits the return of an empty container irrespective of the

condition of the compartment in which it was previously held" (Jones and Walker, 1). After series of innovations and modifications, the RVM is used by many countries, such as Germany, U.K., Sweden, Norway, the United States, Australia, Japan, Brazil and China. For example, China recently adopted thousands of those machines to promote recycling of empty bottles and paper. More than 2,000 Beijing's primary and middle schools now have reverse vending machines, "which pay out coins and stationary in exchange for empty bottles or used books, as part of efforts to boost recycling" (Xin). According to the article, experts expect that "the machines could later be placed in shopping areas, universities and institutes, as well as communities" (Xin). Moreover, there are already established markets for the RVM as well. Some of the vendors include but are not limited to: Tomra of Norway, Wincor Nixdorf of Germany, Envipco of USA, and Envirobank of Australia. Their information is available both online and offline. Figure 10 shows the concept of the RVM in a descriptive way.

Figure 10. A descriptive image of the reverse vending machine. The first concept goes all the way back to 1920s. The image shows two people inserting empty bottles into the machine in return for money. Similar to bottles, metal cans can be inserted as well for money (Reverse Vending's Blog)

RVMs have been popular especially in European countries since 1980s, and active discussions

and recommendations have been made around those time to promote the recycling of the metal cans. Looking into the cases in the U.K., the Rockware scheme was the "first use of reverse vending in the U.K., and set up on a pilot scale in Northampton in October 1985" (Butterwick and Smith, 304) to collect and recover aluminum. Moreover, around this time in 1980s, other European countries started to run the pilot projects. There projects, "taking place in Austria, Germany, Italy and Sweden, have concentrated on the collection of aluminium cans by means of reverse vending machines" (Butterwick and Smith, 304). About 30 years ago, there were already recommendations made in Europe, saying that "possible involvement of large supermarket chains in reverse vending operations worth pursuing" (Butterwick and Smith, 306).

Five criteria for potential solutions to improve the recycling rate of the metal cans are economic, technological, environmental benefits, impact on the recycling rates and active participation and engagement of all the three major stakeholders. From the article introduced in the previous page, the last criteria, which is to promote the active participation and engagement of the major players, is satisfied. Once the government mandates the installation of the RVMs, there would be firms and business entities developing and installing the RVMs. Various individuals would participate in the recycling effort by using those machines. From the article, it is possible to observe that even students in primary and middle schools are able to contribute to the recycling effort with the RVMs. Students participations are especially valuable because they not only engage in the recycling effort as a major stakeholder, but also they learn the value and importance of the recycling in general in their early ages, which provides important educational lessons. Moreover, the RVMs bring environmental benefits and actual impact on the recycling rates, even though there has been no research or data which provide solid and quantitative percentage change of the recycling rates. In Europe, people take "empty bottles and cans back to

the store — this is called "reverse vending" — so that they are in one place for collection and cross contamination is avoided. This leads to high rates of material recycling and also cuts down on the use of vehicles to collect the used items" (Clift, 8). Based on this article, the RVMs improve the recycling rates while providing environmental benefits by decreasing the need and use of vehicles for collecting materials. Therefore, three out of five criteria is likely to be met by adopting and mandating the use of the RVMs.

However, there are high uncertainties found in terms of economic and technological benefits. For the technological benefit, the case in Norway provides that the RVMs provide technological benefits, but they are coming without much support from the government. In Norway, there is a policy called Extended Producer Responsibility (ERP), "a policy principle to promote total life-cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the takeback, recycling, and final disposal of the product" (Røine and Lee, 232-233). ERP is a principle that is in line with the government mandated way to promote the resource circulation. In Norway, a major vendor of the RVMs, Tomra, produces reverse vending machines for used beverage containers. According to a study by Røine and Lee, the company has constantly made technological improvements as well as entirely new products since 1972, but it was not the Norwegian ERP principle and policy that brought the technological benefits. In their analysis, "innovations are mainly driven by potential market opportunities, initiated either through policies or through the market itself" (Røine and Lee, 227-228). In other words, while the government policy provided some incentives to drive technological innovations, it is really the economic incentives and benefits that drove the firms to make the technological innovations, bringing benefits to the society. For example, the study introduces a case that "the

share value of Tomra has been very sensitive to the outcome of the German discussion on whether to introduce tax on one-way bottles or not. The Norwegian EPR scheme on [plastic packaging] has not had the same influence, and the explanation, again, is the size of the market" (Røine and Lee, 228). While Tomra is a reverse vending machine for plastic, it still provides a valuable lesson that there has to be a sizeable market opportunity and economic incentives to drive the technological innovations, thereby providing benefits to the entire society. This case study is something that Korean government must be aware if it may choose to adopt the RVMs into South Korea.

The last criterion to look into is the economic benefit. Interestingly, while there has been much research, discussion and articles on suggesting potential ways to improve the recycling rates, research on the real-world implication of those methods, and the economic and financial benefits and costs have not been thoroughly conducted. Only major thing know is that "the recycling of used metal containers, specifically aluminum containers, has been repeatedly demonstrated to save approximately two-thirds the cost of raw materials for making such containers" (Hampson et al., 5) but "bulk of recyclable aluminum still remains unrecycled" (Hampson et al., 5). As confirmed in the section above about the technological implication and benefits, it is really the market opportunity that drives the innovation and technological advance for recycling firms. Looking into the RVMs, they fall under the system called "a deposit-refund system," which "consumers pay deposits that are added to the price of a product and receive refunds when they return the used products" (Numata, 199). One of the potential economic benefits of RVMs is that "Consumers of deposit–refund goods have an incentive to return used products and receive refunds, and a high recovery rate can be attained with low monitoring costs" (Numata, 199). From the government's and general public's perspectives, RVMs provide more

active opportunities to allow the general public to recycle the metal cans, other than door-to-door collection of metal cans, weekly collection of metal cans (if a person lives at an apartment), or general trash cans. However, from the business perspective, the government mandate of RVM's could be viewed as a disaster. According to Numata, from the economic perspective, deposit-refund systems such as RVMs are difficult to implement in the real world "because suppliers, including manufacturers, wholesalers, and retailers, strongly oppose its introduction since it impacts them negatively. This negative impact is huge, particularly for retailers" (Numata, 199). The author points out that the main economic challenge for RVMs is "huge initial cost for establishing the collecting system," (Numata, 200), which involves "establishing collecting systems involves tremendous expenses, especially when the collecting system includes "reverse vending machines," which are automatic machines that enable consumers to return used products and to obtain a refund anytime" (Numata, 200).

Figure 11. A real image of the reverse vending machine, which is ULTRA 48 by Envipco. While it has the maximum capacity to handle 3,244 aluminum cans, installation cost and maintenance cost might be much bigger than the benefits from collecting those cans. (Envipco)

Therefore, based on the economic analysis, the author recommends that to make the deposit-

refund system to be successful, the government should structure the policy in a way that "the government collects all the unredeemed deposits and there is payment of a handling commission," and this mandate "can enable [a country] to maximize the social surplus, while mitigating the negative impacts on retailers" (Numata, 206). This concern on potential negative economic impacts is valid based on Tomra's investor presentation as well. According to their presentation in 2012, due to the installation and maintenance costs, Tomra is already aware that their main customers are retailers, not individuals.

Figure 12. Tomra's analysis of its business areas in RVMs. (Tomra, 30)

According to Tomra, currently the market leader in RVM business globally with about 60+% market share, "30 billion used beverage containers are every year captured by our reverse vending machines" (Tomra, 16) in which RVMs are spread around in Europe, North America and small amount in Japan. Therefore, RVMs may be able to bring economic benefits, but it depends on how the Korean government sets up the policy in the future if the country chooses to adopt and mandate the use of RVMs.

Discussion / Recommendations

It is possible to identify that the Act on Promotion of Transition to Resource-Circulation Society is a great foundation and a starting point to promote the circulation of critical resources. The data and graph from Australia's export case shows that South Korea's reliance on natural resources, especially the metal ores, have been increasing significantly over the last 10 years or so. The data from the Ministry of Environment also shows that unlike other resources such as glasses and paper, the recycling rate of the metals and metal cans have remained low in the last 10 years or so as well. Combining the two sources of information, it is possible to see that the country has not really focused much on recycling the used metals. Rather, the country has kept relying on increasing the amount of imports as South Korea has focused on developing manufacturing industry. However, from the case on the rare earth metals (or materials), the country's future might be in jeopardy if the supply of the natural resources are controlled or limited due to various issues, which may come from depletion, major exporter's quantity control etc. Acknowledging all those factors, the new South Korean government developed the Act and is waiting to be passed to be legally in effect soon. Of course, compared with other countries which have already developed the concept of circulation of resources, such as China and Japan, there are many steps and processes the Korean government should take to make the transition successful. By improving the metal can recycling rate, there is going to be additional supply of recycled metals, which then will promote the manufacturers to increase the use of those metals to produce goods. This virtuous cycle is one of the desired images of the society of resource circulation.

A successful improvement method for the metal can recycling rate must satisfy five different criteria. First, the desired method must be able to engage the three main stakeholders –

the government, the firms, and the general public – to ensure that the effort to improve the recycling rate eventually contributes to the big picture, which is the transition to the resource circulation society. The Chinese Circular Economy Promotion Law shows that the Law mandates the active participation of those three major groups. Second, the desired method must be contributing to the actual increase of metal can recycling rate in a permanent way, not a short-term or temporary increase. Third, the method must bring environmental benefits. Fourth, the method must bring technological improvement and innovation to the society to move forward to promote the transition to the resource circulation society. Lastly, the method must be able to bring economic benefits to the three major stakeholders.

The South Korean government has provided some potential regulations and solutions in various publications. However, they need improvements since they are either not concretely developed or do not satisfy all the five criteria discussed in the study. Therefore, keeping them in mind, this study proposes the mandate of the use of the reverse vending machines, and recommends the inclusion of this option in the detailed action plans of the Act. The RVMs are already used in practice in many European countries and Americas, while the use of it is not that popular in Asia yet. This concept was also introduced in a government-published document. Recognizing that a successful recycling program does not happen in a short period of time, and requires careful analysis and research, this study uses the five criteria established and looks into this option.

Engagement of the Three Major Shareholders

It is likely that RVMs are going to satisfy this criterion, since this option engages the government by mandating the installation and use, the firms by installing, maintaining and

receiving profits (or incurring costs), and the public by actively using RVMs to engage more in recycling activities. To move forward, future studies should focus on public's intention to use and potential behavioral change. From the general public's perspective, while very small number of RVMs does exist in Korea, most of the people are used to recycle metal cans by traditional methods (door-to-door collection, weekly apartment-level group collection or trash can). Therefore, there should be a study and effort focusing on educating customers and understand how they perceive the mandate of the use of the RVMs.

Actual Impact on the Recycling Rate in the Long-Run

From many studies referred in this research, RVMs do contribute to the increase of the recycling rate of the metal cans. However, there has not been publicly available statistics or data stating exactly by how much the rate changed in a given period of time. To solicit the widespread support on the use of the RVMs, future studies should focus on doing a case study to collect data on changes of the recycling rate or the change of the amount of the metal cans collected in a given period of time on locations where the RVMs are installed in South Korea. If it limited, it might be possible to conduct future studies in one of the European countries such as Switzerland or Germany where the uses of the RVMs are widespread.

Environmental Benefits

As this study points out, while RVMs bring environmental benefits by reducing energy consumption and decreasing the excavation of new natural resources, it is difficult to quantify those benefits. There have been attempts to quantify the environmental impacts of the RVMs, which the effort is mostly led by the firms that manufacture RVMs.

Technological Benefits

From Tomra's case in Norway, it was possible to find out that the company has constantly made technological improvements as well as entirely new products since 1972, but the innovations were mainly driven by the business opportunities and potential market opportunities, not the Norwegian government policy or mandate. Moreover, it should be noted from the Chinese Circular Economy Law and Tomra's case that the government may support the research and development of technology, but the government does not actually develop the technology or makes the innovation take place. From the government's perspective, it might consider mandating the use, but leave the technological development and innovations up to the firms that produce RVMs. In other words, the government should be able to set the table, but should not necessarily direct firms and people what kinds of food be on the table. Moreover, the study also shows that future studies should show whether South Korea has a sizeable market opportunity and economic incentives to drive the technological innovations, thereby providing benefits to the entire society.

Economic Benefits

It is true that RVMs do incur large amount of initial costs to establish, and costs continue to occur to maintain the installed RVMs. This might become a big burden for organizations that are planning to install the RVMs in their organizations or firms, which are likely to be retailers (such as grocery retails from Tomra's case). To quantify and see the economic impact of the RVMs, future studies should focus on the real-world implication of RVMs, and the economic and financial benefits and costs, which in fact have not been conducted much. The government should also design the mandate in a way that provides incentives for the organizations installing

RVMs so that they do not suffer from the potential impact or burden with unbearable losses. An exemplary recommendation is that the government should structure the policy in a way that government and organizations share the benefits gained from RVMs.

Conclusions

This study provides an overview of the Korean government's effort to make the transition from a linear consumption based economy to a sustainable society where resource circulations are greatly promoted. With this in mind, we focused on identifying key criteria of the potential solution to improve the metal can recycling rate, and recommend that adopting the reverse vending machines could boost the recycling rate of the metal cans. The implementation should be done after careful, further research and mandate written as the action plan. I hope to have sparked the discussion on the significance of the recycling of various resources, thereby leading to a transition to the resource-circulation society for Korea.

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