Effects of Singe-Person Household Ratio in the Entire Household on the Municipal Solid Waste in Korea

By

SIM, Boeun

THESIS

Submitted to

KDI School of Public Policy and Management

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Committee in charge:

Professor Yang, Hee-Seung, Supervisor _____

Professor Lee, Jongyearn _____

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ABSTRACT

Effects of Single-Person Household Ratio in the Entire Household on the Municipal Solid Waste in Korea

By

Boeun Sim

This study was undertaken to identify the effects of single-person household on municipal solid waste to find out specific and accurate causes and to improve waste management. Using the "Census of Waste" of the Ministry of Environment and the "Census of Population" of the National Statistical Office in 2010-2016, this study analyzed the correlation between single-person household ratio in the entire household and municipal solid waste generation in terms of material characteristics and places of occurrence. The single household has a slightly negative correlation to municipal solid waste, this is because the effects on the gender and age of single households were different. the effects of gender are a generally similar direction to waste in terms of the youth and elderly. In the case of the middle-aged group, however, the effects are literally different. The middle-aged male's single-person household was a strong positive correlation between household waste, and food and plastic waste in all workplaces, whereas the female's group has no significant correlation with food and plastic waste. This paper shows that the youth and elderly generally have a negative correlation to MSW generation whereas the middle-aged have a positive generation in ages, also, the male has a positive correlation with food and plastic waste while the female has a negative correlation with solid and food waste. This paper is said that gender and age are an essential consideration when comparing the effect of single households, furthermore, the act of reducing waste should be considered each condition in a single-person household.

Keywords: Single-person Household; Municipal Solid Waste; Food Waste; Plastic Waste; Fixed Effect; South Korea

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1 Introduction

The development of the world's economic society has enabled us to lead not only a stable life but also a rich one, with abundant resources and sophisticated technology. However, we are draining resources that are essential for life by over-consuming and wasting them under the name of satisfying our needs. Resource management is an essential part of sustainability efforts due to them being limited. In 2007, The world's material consumption reached 92.1 billion tons and a 254 percent increase from 27 billion in 1970, with the rate of extraction accelerating every year since 2000(UN, 2019). The natural resources to meet one's needs throughout their lifetime was 8.1 tons in 1990 but rose to 12 tons in 2015. The amount that can meet our desire is excessive, resulting in waste. We should try to reduce waste emission, since this increase in waste affects not only the environment but also humanity directly and indirectly (UN, 2019). Several countries have set official goals to reduce waste, one of which is the SDG's Goal 12. Specifically, food waste is related to food security worldwide, because it is correlated with loss, so proper food management could narrow the gaps in its supply and demand.

Meanwhile, the development of economic society has also caused a change in people's lifestyles. The traditional large family unit in Asia is becoming a small family unit, with only two or three members, as Single-person Household (called sgHH) is rapidly growing. In the case of South Korea, the number of sgHH escalated due to complex social phenomena in changes of lifestyle values and marriage amongst the younger generation, raising the number of old people living alone, and middle-aged divorcees. The increase in sgHH shows a different lifestyle than that of the traditional generations, with different consumption behaviors, which affects not just the social and demographic aspects, but also all the market where we sell and buy goods and services

that make up the concept of Solo Economy (Shin, 2014). The consumption propensity of sgHH has affected the market and steadily increased, playing a central role in determining the consumption trend. According to a 2013 survey by the Korea Chamber of Commerce and Industry, single-person households were nearly twice as likely to consume as three or four people households (K. A. Lee & Kwak, 2015). Changes in the pattern of consumption result in the quantity and distribution of waste directly caused by it. As the number of sgHH grows, the type of consumption that seeks convenience and efficiency came to involve the market for small home appliances, goods, and packages (KOTRA, 2014:2015). Therefore, the lifestyle and consumption pattern of a sgHH changes the status of waste emission.

The purpose of this study is to analyze the effects of the increase in the sgHH ratio in entire household on waste emission. To analyze that, the demographic and social factors that contribute to the generation of waste are set as control variables: population density and structure is a Demographic Characteristic and GRDP and Urbanization are Socioeconomic Characteristics. The share of the sgHH which is specified by sex and age is set as the explanatory factor to determine the degree of impact on solid waste, food waste, and plastic waste in the household and business sector. The scope of this study is from 2010 to 2016 with observation in the province and city units. Of the seventeen provinces, Sejong (New since 2014) and Jeju Island are excluded as to problems in the statistical setting. Meanwhile, Year and Region variables were set up as the Dummy variable in consideration of time and regional fixed effect.

The study consists of the following. After looking at the advanced studies in the second sector and then describing the waste status of Korea in the third, the sgHH status in Korea in the fourth section was summarized. The fifth section deals with overall

research methodology and has information on data introduction and analysis models. The study result of the sgHH impact is summarized by total waste, food waste, and plastic waste in the sixth section. Finally, in section seven, the author summarizes this study and provides implications for reducing waste generation.

2 Literature Review

Various studies analyze the factors which impact on waste generation. In the advanced studies, the Municipal Solid Waste, called MSW, was studied from a demographic and socioeconomic perspective. In terms of demographic impact, the number and density of population (Daskalopoulos, Badr, & Probert, 1998; Hong & Seo, 2006; Seong & Lee, 2005), the population structure by age (Schanes et al., 2018; Yoo, Kweon, & Yu, 1996) and household types (Kolekar, Hazra, & Chakrabarty, 2016; C. K. Lee, Lee, Ryu, & Kweon, 1998; Thanh, Matsui, & Fujiwara, 2010) are actively studied . The effects of socioeconomic factors such as GDP and GRDP, Urbanization levels, and industrial structure were also studied by country and region from a macro perspective. On the other hand, studies on the effects of an individual's propensity to generate waste remain sluggish.

The population has been addressed as the most important parameter for waste generation, since MSW is the result of direct human activities (Daskalopoulos et al., 1998; Seong & Lee, 2005). Many studies have suggested that the population has a static correlation with MSW generation (Seong & Lee, 2005), but some studies suggest that the number of people has a weak correlation (Hong & Seo, 2006). In Kolekar (2016), individual lifestyles and consumption habits change depending on the type of household, which changes the amount and conditions of waste emissions. In the case of Thanh

(2010), MSW has a strong correlation with population density and places where enough urbanization has happened. Also, many studies have shown that MSW is affected by the proportion of infants and senior members in the family (Schanes et al., 2018). Besides, MSW, especially food waste, has strong negative correlations with family size (C. K. Lee et al., 1998; Schanes et al., 2018; Thanh et al., 2010). It means that several studies have been conducted as factors affecting waste generation, such as population number, density and structure from demographic causes.

The level and activity of an economy and the urbanization as socioeconomic factors generally have a positive correlation with MSW generation. Urbanization causes an increase in urban population and changes in people's consumption patterns with increased population density. This increases the heterogeneity and quantity of MSW (Buenrostro & Bocco, 2003; Daskalopoulos et al., 1998; Li, Fu, & Qu, 2011). Also, the studies of MSW caused by the food industry are developing, because the proportion of processed and convenient food has grown, as industrial development emphasizes convenience and efficiency (Buenrostro & Bocco, 2003). Also, the economic level is an important factor, as it speaks of one's ability to consume goods. So, GDP has been heavily utilized as a parameter to describe this level of economy (Cohen, 2004; Daskalopoulos et al., 1998). Yan (2003) says, however, that there was an obvious invert U-shaped curve for GDP and MSW generation between 1978 and 2006, while studies show that GDP and MSW generation have strong positive correlation (Hong & Seo, 2006). Xiao also published that the relationship between MSW and income changed from positive to negative correlation in 1995, in Beijing, China[1]. In other words, it is not

[1] *It is considered as the Kuznets theory which says that economic growth and environment pollution have a negative correlation after reaching the peak point when environment pollution increases due to economic growth.*

an unconditional static relationship between GDP and MSW generation. Also, it may be difficult to take accurate measurements, because urbanization is a phenomenon of various and complex changes, such as migrant population, economic activity, and human epidemiological activities.

There are rarely studies about the effects of recognition and behavior of individuality on MSW generation. Recognition of waste disposal, planned behavior, and abundant living satisfaction have had positive effects on reducing waste, affecting individual consumption patterns (Griffin, Sobal, & Lyson, 2009; Russell, Young & Unsworth, 2017; Schanes et al., 2018). However, there is no evaluation of the significant effects.

As a result, studies have been actively conducted on factors affecting waste generation, such as demographic, socioeconomic and personality of terms, but the effects of each factor and their relationship with waste generation vary depending on which variables are controlled or what kind of waste is being analyzed. The number of people has had a positive impact on MSW generation, but it was less significant. Also, there were differences in size and structure of the households which are studied as causes of waste, but there was a lack of specific research on the single population. Many studies used GDP or GRDP as a parameter to analyze socioeconomic aspects, but different correlations were found depending on the situation. An Individual's propensity is generally known to affect their consumption, but studies that have grasped the specific extent of it have been incomplete.

In an advanced study, many explanatory variables affecting MSW generation have been studied, but the specific analysis of each factor has been poor. Also, there have been many studies that analyzed the effects of household types, but the study of sgHH is acknowledged as a key factor these days but has not yet been considered. Therefore, this

current study should analyze the effects of sgHH on MSW generation which have not been not performed in previous studies, and further attempt a comprehensive analysis of the degree of impact in each place, and the kind of materials, such as solid, food and plastic waste, by classifying household and business waste.

3 Municipal Solid Waste

Household Solid Waste (HSW) accounts for 85% of all MSW as of 2016 in Korea (Ministry of Environment, 2008). 60 percent of all HSW is recycled (Figure 2). In the United States, 75 percent of MSW is generated from households, and only 21 percent of HSW is recycled (Oribe-Garcia, Kamara-Esteban, Martin, Macarulla-Arenaza, & Alonso-Vicario, 2015). China disposes of 95 percent of MSW by using the landfill methodology (Xiao, Bai, Ouyang, Zheng, & Xing, 2007). Considering these situations, Korea's recycling rate seems to be relatively high. The daily household solid waste discharge was 1.04kg/person in 2016 in Korea, compared to the OECD average of 1.45kg/person (Japan's 0.95kg/person, U.S.' 2kg/person), which is one of the lowest waste discharges (OECD, 2014) (Figure 1).

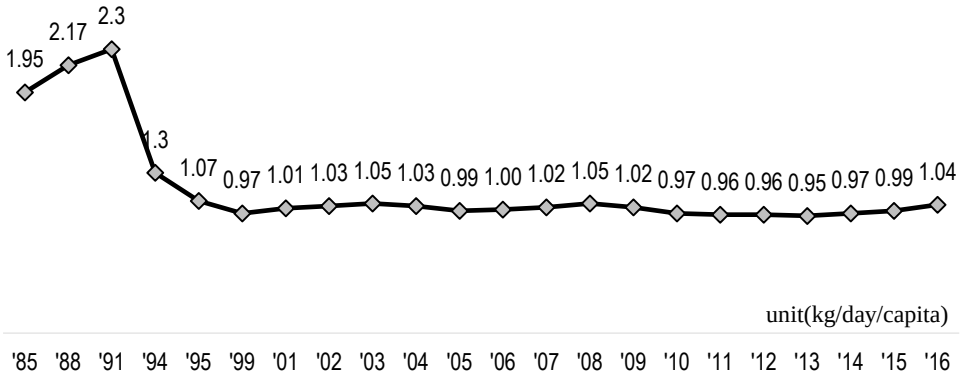

Figure 1 Disposal of MSW, 1985 to 2016 (in kg per person per day)

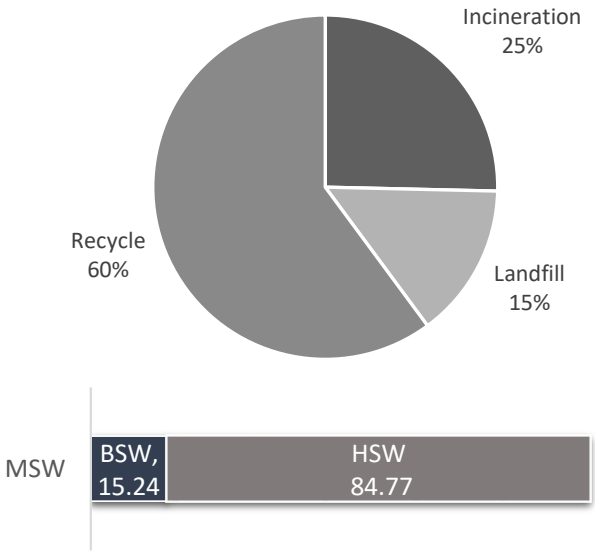

Figure 2 Distribution of waste by methodology and generation area

Table 1 Municipal Solid Waste by Region

Province	density	Solid Waste in Household (HSW)		Solid Waste in Business (BSW)		Municipal Solid Waste (MSW)	
		ton/day	kg/capita/day	ton/day	kg/capita /day	ton/day	kg/capita /day
Gangwon-do	90	1858.90	1.21	320.20	0.21	2179.10	1.42
Gyunggi-do	1237	9369.50	0.76	2492.60	0.20	11862.10	0.96
Gyeongsangnam-do	317	3445.10	1.51	506.30	0.22	3951.40	1.73
Gyeonsangbuk-do	141	2503.40	0.93	382.00	0.14	2885.40	1.08
Gwangju	2997	1086.60	0.74	160.60	0.11	1247.20	0.85
Daegu	2786	1127.70	0.91	265.00	0.21	1392.70	1.12
Daejeon	2848	1406.70	0.93	221.80	0.15	1628.50	1.08
Busan	4477	2847.10	0.82	505.10	0.15	3352.20	0.97
Seoul	16263	8750.90	0.89	857.10	0.09	9608.00	0.98
Ulsan	1099	1420.50	1.22	170.90	0.15	1591.40	1.36
Incheon	2736	1837.80	0.63	543.20	0.19	2381.00	0.82
Jeollanam-do	146	1742.10	0.92	224.70	0.12	1966.80	1.04
Jeollabuk-do	227	1599.50	0.86	248.00	0.13	1847.50	1.00
Chungcheongnam-do	258	1811.40	0.95	507.50	0.27	2318.90	1.22
Chungcheongbuk-do	216	1969.90	1.25	144.50	0.09	2114.40	1.34

As shown in Table1, the HSW (kg/capita/day) in provinces is generally similar, but Daegu, Daejeon, Busan, Seoul, and Incheon, which are more densely populated, did not

exceed 1kg per person, whereas in Gyeongsangnam-do, Ulsan, Chungcheongbuk-do it was higher than in other provinces. While most provinces present the same patterns as conventional studies (Thanh et al., 2010), it is difficult to find a link in some cities, such as Gyeonggi-do, Gwangju, Chungcheongnam-do. Therefore, it can be assumed that other regional and individual characteristics besides population density have affected regional differences.

4 Single-Person Households

The number of sgHH in the country have been on a steady rise due to the increase in non-marriage and divorce, along with the growing number of Single Elderly Households, because of an aging problem. The development of the economic society and the sgHH caused a new consumption trend, which affected waste generation, and this became an important factor to be addressed in MSW management.

The share of sgHH in Seoul(1.14million) and Gyeonggi-do(1.07million) account for about 40 percent of the whole sgHH in Korea, and the ratio of men in their 20s and 30s is on the rise, with no significant differences between men and women (Statistic Korea, 2018). As shown in Figure 3, the average sgHH in Korea stood at 27.6 percent as of 2016, a steady has increased since 2000, and is forecast to surpass 30 percent soon. The interesting points are that the age structure of a sgHH varies by region (Table 2). With the relative urbanization taking place, Seoul, Gyeonggi-do, Ulsan and Daejeon – large cities with active working markets – dominated the youth and senior-aged single households, with the ratio of one elderly single household in Gyeonsangbuk-do, Jeollanam-do, and Jeollabuk-do. This not only affects the work performance associated with economic activities in the region, but also the overall living environment, so the

impact of the sgHH increase varies depending on the type of sgHH. Additionally, as per Table 1, the ratio of the sgHH is not the same as the number of sgHH, due to the difference of density. In other words, the correlation between daily waste generation per person is studied according to the weight of a sgHH.

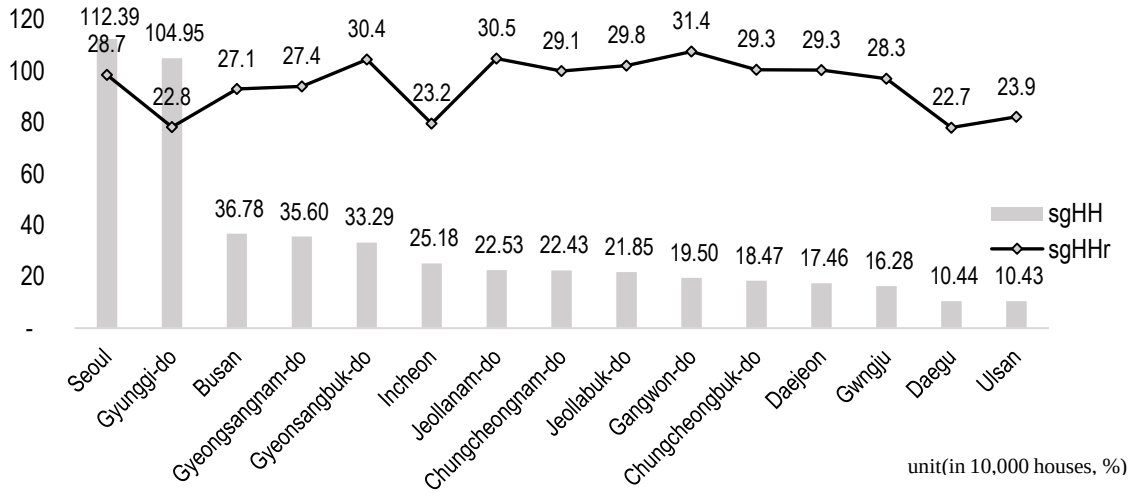

Figure 3 Single-Person Household in 2016

Table 2 Single-Person Household, detail in 2016

Province	sgHHr	sgHHr_2039	sgHHr_4064	sgHHr_over65	sgHHr_f	sgHHr_m
Gangwon-do	31.35	9.58	12.89	8.88	15.34	16.01
Gyunggi-do	22.79	8.03	10.23	4.52	10.51	12.28
Gyeongsangnam-do	27.41	7.18	11.84	8.39	14.12	13.29
Gyeonsangbuk-do	30.45	8.54	11.68	10.22	16.14	14.31
Gwangju	28.27	11.17	11.37	5.73	14.02	14.25
Daegu	22.74	6.97	10.20	5.57	12.31	10.43
Daejeon	29.25	13.44	10.70	5.11	14.24	15.01
Busan	27.10	8.18	11.34	7.58	14.87	12.23
Seoul	28.71	13.54	10.15	5.02	14.95	13.75
Ulsan	23.94	8.18	11.33	4.43	10.48	13.46
Incheon	23.20	7.42	10.78	5.00	11.00	12.20
Jeollanam-do	30.55	6.08	11.47	13.00	16.99	13.56
Jeollabuk-do	29.77	8.26	11.18	10.33	15.87	13.90
Chungcheongnam-do	29.13	10.00	10.79	8.34	14.44	14.69
Chungcheongbuk-do	29.29	9.74	11.70	7.85	14.56	14.73
Average	27.60	9.09	11.18	7.33	13.99	13.60

5 Methodology

5.1 Data

The Ministry of Environment conducts a nationwide waste investigation every year, categorizing and managing waste according to the type and method of disposal. Municipal Solid Waste is the kind of waste which consists of things that people dispose of in a daily basis, so it can be classified as occurring at home. In this study, the MSW data for seven years from 2010 to 2016 are classified by type (total, food and plastic waste), and waste status is based on the site (household, business). The data for sgHH was calculated from the Korean census. Its share was obtained by dividing the total number of households by city. Also, the raw data of a sgHH contains information about sex and age that we can consider as subcategories. Therefore, the scope of the sgHH was set up for the youth (age 20 to 39), the senior (age 40 to 64), and the elderly (age 65 or older) that can study the effects of the characteristics of sgHH on waste generation. However, the 2011-2014 data of sgHH ratio was calculated using the average annual population growth rate, since the census was conducted on a five-year basis before 2015.

The number of people according to age by region was extracted from the "Resident registration population investigation" of the National Statistical Office. The GRDP was collected and integrated from regional statistics provided by each metropolitan city to create the GRDP by city. Of the raw data of GRDP, both total and from accommodations and restaurant businesses were extracted for analysis. Urbanization ratio is an indicator of the progress of urban settings through the proportion of residents in urban and rural areas. All data is registered in the National Statistical Portal, with the data unit having a total of 219 cities and 15 municipalities (excluding Sejong and Jeju). The research range is from 2010 to 2016

Table 3 Data Description

Sort	Char	Variable	Unit	Mean	Std. Dev.	Min	Max
Dependent Variable	Municipal Solid Waste	total	kg/person/day	1.0304	0.4182	0.3188	4.3681
		plastic		0.0228	0.0270	0.0000	0.5372
		food		0.2287	0.1144	0.0000	1.1447
	MSW in Business	total		0.1554	0.2039	0.0000	3.1716
		plastic		0.0034	0.0162	0.0000	0.5282
		food		0.0231	0.0341	0.0000	0.3808
	MSW in Household	total		0.8750	0.3400	0.3188	3.7636
		plastic		0.0195	0.0212	0.0000	0.2636
		food(1)		0.2055	0.1001	0.0000	1.0696
		food(2)		0.0146	0.0279	0.0000	0.2664
Explanatory variable	SgHH(3)	sgHH	Ratio	0.2756	0.0541	0.1413	0.4555
		2039		0.0712	0.0421	0.0112	0.2761
		4064		0.1024	0.0189	0.0537	0.2104
		Over 65		0.1014	0.0633	0.0227	0.2781
		Female		0.1528	0.0457	0.0624	0.2927
		Male		0.1225	0.0283	0.0648	0.3165
Demographic Effect	population	Density	Capita/cubic meter	4023.264	6335.282	19.35	28731.19
		Female	Ratio (*/Pop)	0.4989	0.0118	0.4332	0.5249
		Male		0.5012	0.0118	0.4753	0.5671
		Below 9		0.0830	0.0204	0.0386	0.1552
		2039		0.2570	0.0524	0.1439	0.4091
		Over 65		0.1706	0.0779	0.0521	0.3712
Socioeconomic Effect	GRDP	whole Ind.	Billion won	14,671.07	20,759.62	5.59	134,893.50
		Food Ind.		348.68	420.91	6.97	3,534.92
	Urbanization	Urbanization(4)	Ratio	0.7304	0.2777	0.0000	1.0000

(1) Amounts of food waste in food waste disposal bag

(2) Amounts of food waste in general solid waste disposal bag

(3) It is a ratio of single-Households in whole Households in age and sex. "2039" means from 20 to 39 years old (4064 is from 40 to 64 years old, over 65 is over 65 years of age)

(4) The ratio of habituating resident in Urban comparing Rural in Region

5.2 Modeling

The regression model was used as a factor analysis model for MSW generation in many studies because of being able to consider interrelationships between various socioeconomic factors (Oribe-Garcia et al., 2015). Sun (2017) showed that the nonlinear models are better suitable for the demographics sector (number of residents, households, and tourists) than linear models. In this study, logarithms were converted to MSW and sgHH to make them suitable as well. Also, the criteria were based on the annual unit and municipality, and the models of the study are as follows.

$$lnY_{it} = b_0 + b_1 lnS_{it} + bX_{it}^{'} + a_i + \epsilon_{it}$$

Y_{it} : Municipal Solid Waste in Household and Business
S_{it}^{*} : Ratio of single-person household in Whole Households
X_{it}' : Demographical and Socioeconomic Effects.
α_i : Time-invariant Variables (Year, City)
ϵ_{it} : Error Term

lnY_{it} is a logarithmic conversion variable of MWS generation per person per day in the *i*th city and the *t*th year. Y consists of the total, food, and plastic waste in MSW. lnS_{it} is also the logarithmic variable of the share of sgHH to the total household. These are set by age (age 20 to 39, 40 to 64, over 65) and sex (male and female). X_{it}' is a control variable for other factors that affect MSW generation. It involves demographic factors (population density and structure) and socioeconomic factors (GRDP, economic activity, and urbanization) as control variables in this study.

The unit of population density is capita per cubic kilometer, and the populational structure sets the ratio of children aged 0 to 9 and the ratio of elderly aged over 65 as representative variables of the entire population, because these are characteristics that

affect MSW generation. GRDP can identify regional economic levels and characteristics of activities by treating the overall GRDP and the GRDP of the food industry. Its unit is a million Korean Won. The unit of urbanization utilizing the proportion of the population residing in urban areas is the ratio. a_i are the time-invariant variables that reflect the unique attributes, relating to fixed effect. It was applied to this equation using dummy variables.

6 Result and Discussion

The estimated results in this study are compiled from Table 4 to Table 7. Table 4 is the table of waste generation by household, business, and entire territory, depending on the share of a sgHH. Table 5 dedicates the effects of the sgHH share by sex, as male and female, on waste emission. Table 6 accounts for its effects by age and Table 7 is by sex and age. It should be noted that these equations, which are inserted from Table 5 to Table 7, are isolated by columns, inking using marking the number, under the same control variables (population density, child rate, urbanization, total GRDP, and food industry GRDP). These were placed in the same row for editorial problems, and, to clarify this, they are stated (1) to (11). For example, formula (5) is equivalent to Waste=female sgHH ratio+ control variables. This is a fixed-effect model in terms of time and region.

6.1 The Effect of Single-Person Households on Waste

The change in the number of waste emissions by the proportion of sgHH from the total number of households is as shown in Table 4. The increase in the percentage of the sgHH ratio affected total solid waste and food waste emissions from workplaces. The total amount of solid waste in the house is seen to be 0.233 percent less when there is a

sgHH increase of 1 percent, which can be said to be 0.233 percent less waste per person than the total households' emission. The daily average per person of waste at home is 0.875 kg, emitting about less 20.4 g per person per day in the sgHH. The sgHH gets less 1.99 percent of food waste generated at the workplace; That means it is less 0.46 g per person per day, given 0.023 kg of average emission in the workplace. For plastic waste, the difference between the proportions of sgHH was not statistically significant. Overall, it is inferred that the effect of the ratio of sgHH to all is statistically weak. Besides, the total solid waste and food waste at workplaces does not seem to have a strong significant impact on the generation of waste by a sgHH. However, this is the result of an analysis on the entire single population, which shows a clear difference when it is analyzed by sex and age.

Table 4 The effect of single-person households on waste

Var	Total Waste			Food Waste			Plastic Waste		
	HH	B	W	HH	B	W	HH	B	W
Single Household(log)	-0.233*	-1.217	-0.158	0.141	-1.991*	-0.149	-0.0820	-0.206	-0.284
	[0.114]	[0.681]	[0.144]	[0.198]	[0.852]	[0.168]	[0.416]	[1.211]	[0.371]
Population Density(log)	-0.131*	0.0460	-0.0881	0.0450	-0.431	0.0130	0.0668	0.764	-0.102
	[0.0584]	[0.307]	[0.0737]	[0.101]	[0.345]	[0.0860]	[0.213]	[0.434]	[0.190]
Child Ratio	-1.862	-8.450	-3.024	-2.628	-7.350	-2.994	-8.638	-23.75*	-3.757
	[1.340]	[7.310]	[1.690]	[2.326]	[8.675]	[1.974]	[4.881]	[11.03]	[4.353]
Urbanization	0.334*	1.457	0.239	0.167	0.578	0.116	0.655	-0.541	0.469
	[0.153]	[0.845]	[0.193]	[0.266]	[0.998]	[0.225]	[0.558]	[1.386]	[0.497]
Total GRDP (log)	-0.00508	-0.116	-0.00732	0.0279	-0.167	0.0138	-0.0371	0.0971	-0.0593
	[0.0197]	[0.104]	[0.0248]	[0.0342]	[0.122]	[0.0290]	[0.0718]	[0.150]	[0.0640]
GRDP in food Ind(log)	0.0917**	0.457**	0.125***	0.0425	-0.230	0.0203	0.391***	0.734*	0.315***
	[0.0290]	[0.173]	[0.0365]	[0.0503]	[0.283]	[0.0427]	[0.106]	[0.309]	[0.0941]
Year	Yes								
City Dummy	Yes								
N	1404	1273	1404	1404	1098	1404	1404	935	1404
adj. R-sq	0.826	0.626	0.761	0.759	0.537	0.812	0.661	0.568	0.651

* $p < 0.05$, ** $p<0.01$, *** $p<0.001$

As shown in Table 4, it can be inferred that the amount of waste per person per day decreases by 0.13% as the population density increases by 1% at a statistically significant level. Characteristically, as the proportion of children increased, the number of plastic wastes generated by workplaces decreased by 23.75%, which has a negative perception of the use of plastic in child-rearing environments, which can be attributed to a relatively lower consumption. Although the effect of the overall GRDP is not statistically significant, the GRDP for the food industry has, in fact, shown a statistically significant correlation between changes in total and plastic waste except for food waste. In particular, the relative impact on waste generated by businesses was greater than that on waste generated by homes, from which can be inferred that the increase in GRDP in a particular industry indicates that its economic activity is lively, and therefore represents a positive correlation between active consumption and waste. In the case of food waste, it can be inferred that, as of the development of the food industry, the correlation between GRDP and waste has weakened, as well as developing a competitive strategy for reducing food waste at the same time.

6.2 *The Effect of Single-Person Households on Waste by Sex*

Table 5 divided the sgHH into female and male sgHH and analyzed the statistical differences between these groups. In the case of female sgHH, there was a negative correlation between total waste and food waste. Especially, the amount of food waste was less 2.71 percent than produced by households in the 99.9% significance. This can be attributed to women spending relatively less on dining out than men. Meanwhile, there were no statistically significant differences in the male sgHH except for the entire food waste and plastic waste, and, unlike the female sgHH, the male sgHH was found to

have a positive correlation between food and plastic waste when the male population increased. Statistically speaking, it can be said that 0.236% of food waste and 0.504% of plastic waste produce more than a household's emission. This showed that sgHH had different effects on waste emissions depending on gender.

Table 5 The effect of single-person households on waste by sex

Var		Total			Food			Plastic		
		HH	B	W	HH	B	W	HH	B	W
(1)	Female Single Household(log)	-0.133	-0.0601	-1.528**	-0.238	-2.717***	-0.428**	-0.350	-0.772*	-1.174
		[0.0951]	[0.120]	[0.573]	[0.165]	[0.748]	[0.139]	[0.346]	[0.308]	[0.964]
(2)	Male Single Household(log)	-0.102	-0.0442	0.589	0.250	0.719	0.236*	0.181	1.399	0.504*
		[0.0771]	[0.0972]	[0.442]	[0.134]	[0.555]	[0.113]	[0.281]	[0.871]	[0.250]
Demographic control		Yes								
Socioeconomic control		Yes								
Year		Yes								
City Dummy		Yes								
N		1404	1404	1273	1404	1098	1404	1404	1404	935
adj. R-sq		0.826	0.761	0.627	0.760	0.541	0.813	0.661	0.653	0.569

* $p < 0.05$, ** $p<0.01$, *** $p<0.001$

6.3 The Effect of Single-Person Households on Waste by Age

Table 6 identified the differences between sgHH by age and total MSW. In this study, the age range of sgHH was set from 20 to 99 years old, and they were grouped from 20 to 39 (young people), 40 to 64 (middle-aged people), and 65 or older (old people). Studies show that the sgHH of young people overall produces a greater amount of total waste, food waste, and plastic waste than the standard household at statistically significant levels. In particular, the total solid waste generated by the workplace (average 0.15 kg/person/day) increases by 0.47% as the number of young people increases, causing an additional 0.7g of household waste per day per person. Looking at the single population of middle-aged people, the total amount of waste produced by households is

0.35% less than that of the entire household, but 4.67% more plastic is produced in the workplace. This is caused by the middle-aged sgHH being the main consumers of the restaurant industry, and there being a trend of "consideration for convenience" rather than "green consumption" in this age group. The difference in age-related waste emissions is evident in older people. Older people have negative correlations with total waste, food waste, and plastic waste, especially for food waste and plastic waste generated at workplaces. This is because of acute passiveness about consumer activities, especially for single aged households, and having a very weak role as consumers in the food industry, especially when dining out, because of its huge perception of it being a luxury.

Table 6 The effect of single-person households on waste by age

Var		Total			Food			Plastic		
		HH	B	W	HH	B	W	HH	B	W
(3)	sgHH (2039)	-0.0354	0.474*	-0.0240	0.140**	0.434	0.159***	0.127	0.137	0.262**
		[0.0312]	[0.185]	[0.0393]	[0.0539]	[0.232]	[0.0456]	[0.113]	[0.382]	[0.101]
(4)	sgHH (4064)	-0.354**	-0.264	0.158	-0.132	0.782	-0.237	0.358	4.665***	-0.130
		[0.134]	[0.168]	[0.745]	[0.232]	[0.908]	[0.197]	[0.487]	[1.225]	[0.434]
(5)	sgHH (over65)	-0.0700	-1.111**	-0.0284	-0.331**	-1.691**	-0.450***	-0.540*	-1.537*	-0.794***
		[0.0710]	[0.411]	[0.0894]	[0.123]	[0.514]	[0.104]	[0.258]	[0.717]	[0.229]
Demographical control		Yes								
socioeconomic control		Yes								
Year		Yes								
City Dummy		Yes								
N		1404	1273	1404	1404	1098	1404	1404	935	1404
adj. R-sq		0.826	0.627	0.761	0.761	0.536	0.814	0.661	0.568	0.653

* p < 0.05, ** p<0.01, *** p<0.001

6.4 The Effect of Single-Person Households on Waste by Sex & Age

Table 7 is a table designed to analyze Table 5 and Table 6 more specifically. The age of each gender was grouped, and changes in the discharge to waste were estimated for the young, middle and old in the single female and male households. What's interesting is that a group of women and men between the ages of 20 and 39 and 65 years old follows the same direction for waste emissions, whereas in a group of 40 and 64 years old, the amount of waste produced by women and men were correlated in different directions. In women's cases, there were positive correlations of total solid waste, food and plastic waste in the young group, and there were no statistically significant differences in a household. For middle-aged people, a single female household had a negative correlation with household and business-generated household waste and could not account for statistically significant differences in food and plastic waste. However, older people showed strong negative correlations in the total waste, including food and plastic, especially for the portion of food waste produced in workplaces, which was explained at a statistically significant level, by about less 1.59% when the number of elderly households increased by 1%. Women's single elderly households generate relatively small amounts of waste in all areas compared to entire households, indicating a slowdown in the consumption of the elderly population and, for women, at a greater extent than men's (Table 7, (7)). In men's youth, as in women’s, there was a positive correlation in all parts of total, food and plastic waste, but not statistically larger than the beta value of women. In older people, food waste is only negatively correlated, and its size is relatively less than that of older women. Interestingly, a sgHH of middle-aged men had a strong correlation with waste (total, food, and plastics) emitted from the workplace, in particular. When the sgHH of middle-aged men increased by 1%, the total waste generated by workplaces increased by 1.4% with 95% significance, and by 5.36%

with 99.9% significance for plastic waste, 1.85% for food and with 99.9% significance. This can be inferred as a key operator group for waste discharge by a sgHH of middle-aged men. Moreover, the proportion of middle-aged people out of the total single-family population (27.6%) stands at 11.1%, which is relatively higher than that of young people (7.1%). That is another major factor in consumer activity, and, thus, in the ratio of single-person middle-aged men as the main influence.

Table 7 The effect of single-person households on waste by sex & age

Var		Total			Food			Plastic		
		HH	**B**	**W**	**HH**	**B**	**W**	**HH**	**B**	**W**
(6)	sgHH(f)(2039)	0.0113	0.596**	0.0135	0.0924	0.713**	0.143**	0.178	0.266	0.305**
		[0.0303]	[0.189]	[0.0382]	[0.0525]	[0.243]	[0.0444]	[0.110]	[0.350]	[0.0980]
(7)	sgHH(f)(4064)	-0.207*	-1.254*	-0.227	-0.0130	-1.244	-0.213	0.0472	0.795	-0.522
		[0.0990]	[0.586]	[0.125]	[0.172]	[0.811]	[0.146]	[0.361]	[0.998]	[0.321]
(8)	sgHH(f)(over65)	-0.0490	-1.002**	-0.0130	-0.315**	-1.585***	-0.412***	-0.506*	-1.367*	-0.733***
		[0.0640]	[0.370]	[0.0806]	[0.111]	[0.467]	[0.0934]	[0.232]	[0.651]	[0.207]
(9)	sgHH(m)(2039)	-0.0415	0.411*	-0.0243	0.146**	0.313	0.150***	0.0960	0.0762	0.217*
		[0.0302]	[0.178]	[0.0380]	[0.0521]	[0.223]	[0.0442]	[0.110]	[0.378]	[0.0977]
(10)	sgHH(m)(4064)	-0.214	1.411*	-0.0676	-0.175	1.850*	-0.0735	0.305	5.363***	0.382
		[0.110]	[0.621]	[0.139]	[0.192]	[0.749]	[0.163]	[0.402]	[1.011]	[0.358]
(11)	sgHH(m)(over65)	-0.00224	-0.589	0.0674	-0.325*	-0.798	-0.360*	-0.321	-1.518	-0.372
		[0.0957]	[0.545]	[0.121]	[0.166]	[0.656]	[0.140]	[0.348]	[0.919]	[0.310]
Demographical control		Yes								
socioeconomic control		Yes								
Year		Yes								
City Dummy		Yes								
N		1404	1273	1404	1404	1098	1404	1404	935	1404
adj. R-sq		0.826	0.628	0.761	0.760	0.539	0.813	0.662	0.569	0.654

Table 8 the Estimated Result in Municipal Solid Waste (Total)

Sort	Var	des/unit	(1)			(2)			(3)		
			HH	B	W	HH	B	W	HH	B	W
Effect of single-Household	sgHH(f)	sgHH ratio in household(log)	-0.183	-1.426*	-0.0824						
			[0.0992]	[0.592]	[0.125]						
	sgHH(m)		-0.144	0.319	-0.0633						
			[0.0804]	[0.455]	[0.101]						
	sgHH(2039)					-0.0876*	0.273	-0.0508			
						[0.0396]	[0.231]	[0.0500]			
	sgHH(4064)					-0.340*	0.723	-0.268			
						[0.138]	[0.768]	[0.175]			
	sgHH(over65)					-0.146	-0.850	-0.0625			
						[0.0923]	[0.525]	[0.117]			
	sgHH(f)(2039)								0.0964	0.230	0.0610
									[0.0517]	[0.336]	[0.0655]
	sgHH(f)(4064)								-0.176	-1.124	-0.284
									[0.120]	[0.704]	[0.152]
	sgHH(f)(over65)								-0.119	-0.399	-0.0230
									[0.101]	[0.563]	[0.128]
	sgHH(m)(2039)								-0.141**	0.0107	-0.0871
									[0.0449]	[0.279]	[0.0568]
	sgHH(m)(4064)								-0.303*	1.504*	-0.0965
									[0.129]	[0.736]	[0.164]
	sgHH(m)(over65)								0.185	0.0902	0.184
									[0.123]	[0.701]	[0.155]
Demographical factor	Density	capita per cubic meter(log)	-0.132*	-0.0158	-0.0928	-0.142*	-0.176	-0.0922	-0.121*	-0.0288	-0.0589
			[0.0582]	[0.306]	[0.0735]	[0.0584]	[0.309]	[0.0738]	[0.0597]	[0.314]	[0.0755]
	Child	children ratio in population	-2.014	-8.471	-2.977	-2.594	-7.814	-3.538*	-3.227*	-5.581	-3.596*
			[1.349]	[7.368]	[1.702]	[1.383]	[7.628]	[1.748]	[1.431]	[7.968]	[1.811]
Socioeconomic factor	Urban	Urbanization ratio	0.328*	1.220	0.243	0.312*	1.281	0.231	0.308*	1.192	0.218
			[0.155]	[0.852]	[0.196]	[0.155]	[0.853]	[0.196]	[0.155]	[0.853]	[0.196]
	total GRDP	total GRDP(log)	-0.00625	-0.122	-0.00763	-0.00650	-0.113	-0.00767	-0.00147	-0.108	-0.00366
			[0.0197]	[0.104]	[0.0249]	[0.0197]	[0.104]	[0.0249]	[0.0198]	[0.104]	[0.0250]
	food GRDP	GRDP in food Industry(log)	0.0903**	0.439*	0.127***	0.0907**	0.422*	0.127***	0.0970***	0.432*	0.134***
			[0.0291]	[0.173]	[0.0367]	[0.0292]	[0.175]	[0.0369]	[0.0293]	[0.175]	[0.0370]
Year			yes								
City Dummy			yes								
N			1404	1273	1404	1404	1273	1404	1404	1273	1404
adj. R-sq			0.826	0.627	0.761	0.827	0.628	0.761	0.828	0.629	0.761

* $p < 0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Table 9 The Estimated Result in Food Waste

Sort	Var	des/unit	(1)			(2)			(3)		
			HH	B	W	HH	B	W	HH	B	W
Effect of single-Household	sgHH(f)	sgHH ratio in household(log)	-0.163	-2.628***	-0.375*						
			[0.172]	[0.758]	[0.145]						
	sgHH(m)		0.213	0.410	0.149						
			[0.139]	[0.559]	[0.118]						
	sgHH(2039)					0.0807	-0.0314	0.0589			
						[0.0687]	[0.283]	[0.0580]			
	sgHH(4064)					0.0341	1.737	-0.0141			
						[0.240]	[0.939]	[0.203]			
	sgHH(over65)					-0.222	-2.004**	-0.364**			
						[0.160]	[0.650]	[0.135]			
	sgHH(f)(2039)								-0.0296	0.504	0.0314
									[0.0897]	[0.429]	[0.0759]
	sgHH(f)(4064)								0.405	-1.329	0.208
									[0.208]	[1.020]	[0.176]
	sgHH(f)(over65)								-0.323	-1.666*	-0.390**
									[0.176]	[0.718]	[0.149]
	sgHH(m)(2039)								0.124	-0.534	0.0502
									[0.0778]	[0.363]	[0.0659]
	sgHH(m)(4064)								-0.282	1.996*	-0.210
									[0.224]	[0.925]	[0.190]
	sgHH(m)(over65)								-0.0476	0.643	0.0271
									[0.213]	[0.915]	[0.180]
Demographical factor	Density	capita per cubic meter(log)	0.0464	-0.537	0.00428	0.0206	-0.776*	-0.0432	-0.0329	-0.625	-0.0661
			[0.101]	[0.343]	[0.0854]	[0.101]	[0.348]	[0.0855]	[0.103]	[0.352]	[0.0876]
	Child	children ratio in population	-2.872	-8.180	-3.182	-3.846	-3.418	-4.158*	-4.277	-3.350	-4.605*
			[2.338]	[8.737]	[1.978]	[2.400]	[9.144]	[2.027]	[2.483]	[9.387]	[2.101]
Socioeconomic factor	Urban	Urbanization ratio	0.0691	0.195	-0.000914	0.0223	0.351	-0.0452	0.0509	0.182	-0.0266
			[0.269]	[1.003]	[0.228]	[0.269]	[1.004]	[0.227]	[0.269]	[1.003]	[0.228]
	total GRDP	total GRDP(log)	0.0269	-0.172	0.0120	0.0272	-0.150	0.0127	0.0241	-0.138	0.0125
			[0.0342]	[0.121]	[0.0289]	[0.0342]	[0.121]	[0.0289]	[0.0343]	[0.122]	[0.0290]
	food GRDP	GRDP in food Industry(log)	0.0328	-0.315	0.0108	0.0192	-0.445	-0.00251	0.0187	-0.423	0.000457
			[0.0504]	[0.284]	[0.0426]	[0.0507]	[0.292]	[0.0428]	[0.0508]	[0.295]	[0.0430]
Year			yes								
City Dummy			yes								
N			1404	1098	1404	1404	1098	1404	1404	1098	1404
adj. R-sq			0.760	0.541	0.813	0.761	0.541	0.815	0.762	0.544	0.81

$^{*}p < 0.05$, $^{**}p<0.01$, $^{***}p<0.001$

Table 10 The Estimated Result in Plastic Waste

Sort	Var	des/unit	(1)			(2)			(3)		
			HH	B	W	HH	B	W	HH	B	W
Effect of single-Household	sgHH(f)	sgHH ratio in household(log)	-0.312	-1.011	-0.647*						
			[0.361]	[0.969]	[0.321]						
	sgHH(m)		0.108	1.295	0.354						
			[0.293]	[0.876]	[0.260]						
	sgHH(2039)					-0.0351	-0.607	0.0738			
						[0.144]	[0.447]	[0.128]			
	sgHH(4064)					0.678	5.757***	0.286			
						[0.504]	[1.258]	[0.449]			
	sgHH(over65)					-0.685*	-2.941***	-0.730*			
						[0.337]	[0.865]	[0.299]			
	sgHH(f)(2039)								0.134	-1.041	0.166
									[0.189]	[0.578]	[0.168]
	sgHH(f)(4064)								0.565	-0.501	0.0303
									[0.438]	[1.207]	[0.390]
	sgHH(f)(over65)								-0.686	-1.014	-0.730*
									[0.370]	[0.949]	[0.329]
	sgHH(m)(2039)								-0.110	-0.110	-0.0626
									[0.164]	[0.567]	[0.146]
	sgHH(m)(4064)								-0.0376	6.934***	0.0541
									[0.472]	[1.219]	[0.420]
	sgHH(m)(over65)								0.134	-2.599*	0.366
									[0.449]	[1.160]	[0.399]
Demographical factor	Density	capita per cubic meter(log)	0.0637	0.724	-0.125	-0.0218	0.427	-0.215	-0.0329	0.579	-0.175
			[0.212]	[0.433]	[0.189]	[0.213]	[0.432]	[0.189]	[0.218]	[0.435]	[0.194]
	Child	children ratio in population	-8.909	-24.57*	-3.849	-8.616	-12.34	-5.021	-10.17	0.152	-5.746
			[4.911]	[11.13]	[4.368]	[5.041]	[11.78]	[4.485]	[5.228]	[12.38]	[4.649]
Socioeconomic factor	Urban	Urbanization ratio	0.555	-0.901	0.258	0.460	-0.781	0.194	0.493	-0.777	0.192
			[0.565]	[1.398]	[0.503]	[0.565]	[1.379]	[0.503]	[0.566]	[1.368]	[0.504]
	total GRDP	total GRDP(log)	-0.0389	0.0883	-0.0620	-0.0454	0.0828	-0.0635	-0.0411	0.0289	-0.0579
			[0.0718]	[0.150]	[0.0639]	[0.0719]	[0.148]	[0.0639]	[0.0722]	[0.148]	[0.0642]
	food GRDP	GRDP in food Industry(log)	0.381***	0.715*	0.301**	0.348**	0.375	0.272**	0.355***	0.493	0.285**
			[0.106]	[0.310]	[0.0941]	[0.106]	[0.314]	[0.0947]	[0.107]	[0.314]	[0.0951]
Year			yes								
City Dummy			yes								
N			1404	935	1404	1404	935	1404	1404	935	1404
adj. R-sq			0.661	0.570	0.653	0.662	0.582	0.654	0.662	0.589	0.654

$^{*}p < 0.05$, $^{**}p<0.01$, $^{***}p<0.001$

7 Conclusion

Using the "Census of Waste" of the Ministry of Environment and the "Census of Population" of the National Statistical Office, this study analyzed the correlation between sgHH and status of waste. To allow us to see the net effects of sgHH, the factors affecting waste generation, population density, population structure, degree of urbanization, and GRDP were set as control variables, and municipal and provincial data were used for each region during the 2010-2016 period. Since the "Census of Population" was conducted on a five-year basis before 2015, the 2011-2014 data were calculating taking into account annual growth rates.

The ratio of sgHH is about 29.4 percent, and has been steadily increasing, of which middle-aged sgHH is 40 percent. About 34 percent of sgHH aged 65 or older have the characteristics of living in mostly rural areas. Household waste averages 1.11 kg/person/day, of which 0.29 kg/person/day is food waste and 0.11 kg/person/day is the amount of plastic waste. This study unraveled the correlation between sgHH and waste in three areas.

The results of this study are as follows. As the proportion of sgHH increased, the amount of household waste slightly decreased. However, although the proportion of sgHH seems to have a statistically small effect on household waste, this is because the effects on the gender and age of sgHH were different. Differences in household waste emissions (kg/day) were not statistically significant in men's sgHH compared to ordinary households except being a positive correlation between food and plastic waste. However, the single female household had a negative correlation to household waste, food waste, and plastic waste, and, especially in the workplace, the strong negative correlation showed that the single female household reduced 2.27% when the 1% increase happened.

Looking at age-specific effects, young and older people generally showed a correlation between the number of waste emissions, while those aged 65 and older showed a negative correlation in all areas. In particular, the company had a greater beta value than other areas for waste generated by site, because the elderly population had relatively less external and consumption activities. Most interestingly, the age division of the male and female single-person households ended up showing remarkable results in the middle-aged single-person group. Both women and men had a relatively positive relationship with waste at the ages of 20-39, and at the age of 65 or older, a negative correlation was the case. However, in the middle-aged group, women did not account for statistically significant differences in food and plastic waste, even though the negative correlations to the generation of household waste were not explained in the group. In the middle-aged male's single-person household, though, there was a strong positive correlation between household waste, and food and plastic waste in all workplaces. This can be inferred as the reason why the proportion of total sgHH does not seem to have a significant impact on waste generation, due to the conflicting group of middle and middle-aged men.

Table 11 Summary of Results

		Solid Waste			Food waste			Plastic Waste		
sgHH		**HH**	**B**	**W**	**HH**	**B**	**W**	**HH**	**B**	**W**
sgHHr		-0.233*				-1.991*				
female sgHHr				-1.528**		-2.717***	-0.428**		-0.772*	
male sgHHr							0.236*			0.504*
sgHHr(2039)			0.474*		0.140*		0.159*			0.262**
sgHHr(4064)		-0.354**							4.665***	
sgHHr(over65)			-1.111*		-0.331**	-1.691**	-0.450***	-0.540*	-1.537*	-0.794***
female sgHH	2039		0.596**			0.713**	0.143**			0.305**
	4064	-0.207*	-1.254*							
	over65		-1.002**		-0.315**	-1.585***	-0.412***	-0.506*	-1.367*	-0.733***
male sgHHr	2039		0.411*		0.146*		0.150***			0.217*
	4064		1.411*			1.850*			5.363***	
	over65				-0.325*		-0.360*			

$^{*}p < 0.05$, $^{**}p<0.01$, $^{***}p<0.001$

In conclusion, the increase in the ratio of sgHH can statistically account for the effects on waste generation, and since they have different relationships by gender and age, a detailed analysis is required. These differences are affected by the individual's lifestyle, personal values, and level of awareness of waste. In this study, the effects of sgHH were analyzed using macro data, and correlations were derived for specific groups. This means that by analyzing the causes affecting waste generation, the individuality and lifestyle of the groups (medium-female and male single-person groups) that are derived to maximize the policy effect of reducing waste should be identified. Furthermore, a waste reduction policy is needed for sgHH aged 20 to 39, which will become the backbone of future consumption. Many studies have shown that the negative perception of waste is significant (Griffin et al., 2009; Schanes et al., 2018). In the next study, the degree of ignorance of waste can be identified, and autonomous waste reduction can be sought through education. Because the waste that each group affect is also categorized, it is necessary to design a specific reduction policy for that area. The findings suggest that individual waste reduction measures could be proposed for groups and locations of the derived sources of waste.

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