

## Plastic Pandemic caused by COVID-19; Based on Market Price of Recyclable Resources

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### Abstract

Modern people live in the age of plastics. It has been widely used due to its easy molding processing, mass production, and excellent durability. However, over-produced plastics for convenience cause plastic disasters and adversely affect the ecosystem. Since the COVID-19 outbreak, the use of single-use plastic waste due to the use of delivery services has increased. The COVID-19 pandemic has caused a plastic pandemic. Currently, domestic recycling policies depend only on recycling collection companies and market prices of recyclable resources. This paper confirms whether the outbreak of COVID-19 has affected the price of plastic waste. It also shows that the price of plastic waste is more unstable than metals with a high recycling rate. This urges businesses to share the cost of recycling on plastic waste, no longer being dependent on market prices for recyclable resources.

**Keywords** : correlation analysis, t-test, ANOVA, COVID-19, plastic waste.

### 1. Introduction

In 2020, we are fighting the COVID-19 virus. The World Health Organization (WHO) declared a COVID-19 pandemic on March 11, 2020. The WHO divides infectious disease warning levels from 1 to 6 according to the risk of infectious diseases, and the pandemic corresponds to the highest warning level of 6 levels. The pandemic is a global epidemic of a specific disease, and in order to meet this, the infectious disease must spread beyond a specific country to more than two continents. In particular, since the WHO was founded in 1948, there have only been three cases of pandemic declarations: the Hong Kong flu in 1968, the swine flu in 2009, and the COVID-19 in 2020.

Modern people live in the age of plastics. Plastic comes from the Greek word ‘Plastikos (to create a shape).’ It has been widely used due to its easy molding processing, mass production, and excellent durability. However, over-produced plastics for convenience cause plastic disasters and adversely affect the ecosystem.

Since the COVID-19 outbreak, the use of single-use

plastic waste due to the use of delivery services has increased. However, due to COVID-19, the import and export channels were blocked, making it impossible to export plastic recycled raw materials anymore, and at the same time, disposable waste has continued to accumulate. The COVID-19 pandemic has caused a plastic pandemic.

Meanwhile, despite the overproduction of plastic waste, another plastic has been imported to recycle plastic. The Ministry of Environment has imposed import restrictions on three plastic items from June this year to exhaust domestic waste. In order to overcome the trash pandemic, economic and legal regulations on disposable plastics must be actively implemented, but the Korean government's countermeasures are still insufficient. In OECD countries such as Germany and France, the Extended Producer Responsibility (EPR) system has become commonplace. Korea has been implementing EPR since January 2003, but the regulation is weaker than other countries. To make up for this, you need to hold the plastics distribution industry accountable. For example, regulations are needed that make producers bear the cost of the entire recycling process.

According to the data released by the OECD, as of 2016, Korea's annual waste emission per capita was about 385kg, ranking 28th out of 36 countries<sup>[1]</sup>. It is far lower than the 784.6kg of Denmark, which is the num-

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ber one. According to the Greenpeace report<sup>[2]</sup>, the amount of waste per capita in Korea is low, but the proportion of plastic is high, and the recycling rate of plastic is only about 23%. However, this is an estimate, and statistics on the actual amount of recycling have not been established at the national level.

Recently, studies have been conducted to analyze the impact of COVID-19 on single-use plastic waste discharge. Vanapalli *et al.*<sup>[3]</sup> argued that long-term countermeasures should be discussed at the national level before COVID-19 triggers a serious plastic waste disaster. Klemeš *et al.*<sup>[4]</sup> said that as COVID-19 became more serious, the environmental footprint had also soared, and discussed waste management during the COVID-19 epidemic and in post-COVID-19. Sarkodie *et al.*<sup>[5]</sup> announced that the amount of waste has increased nationally by working from home and social distancing. Silva *et al.*<sup>[6]</sup> emphasized the need for active R&D of eco-friendly plastics as COVID-19 is blocking the plastic reduction policy. In addition, various studies have been conducted on the management of increased waste due to COVID-19<sup>[7-11]</sup>.

A domestic recycling company claimed that the value of plastic waste has plummeted due to export and import regulations caused by COVID-19, and the Ministry of Environment has implemented a price index system as a countermeasure.

This paper verifies whether the outbreak of COVID-

19 has affected the price of plastic waste. In addition, it shows that the price of plastic waste is more unstable than metals with a high recycling rate, and urge companies to share the cost of recycling resources for plastic waste.

Section 2 briefly shows the current status of COVID-19 confirmed cases in Korea, and Section 3 introduces the data sets. Section 4 analyzes the market price fluctuation of plastic waste through statistical analysis, and Section 5 concludes.

## 2. COVID-19 Cases in Korea

The first confirmed cases of COVID-19 in Korea were from overseas, and a total of 11 confirmed cases occurred in January. After that, the number of confirmed cases occurred sporadically in February and March, and the number of confirmed cases gradually decreased through telecommuting and social distancing. However, confirmed cases occurred sporadically again in August and September.

Figure 1 shows the cumulative number of confirmed patients per month, excluding those entering overseas from January to October. The number of confirmed cases in March was the highest at 6,419, followed by the number of confirmed cases in August at 5,474. The number of confirmed cases in October was 2,444, and the cumulative number of confirmed cases was 24,745.

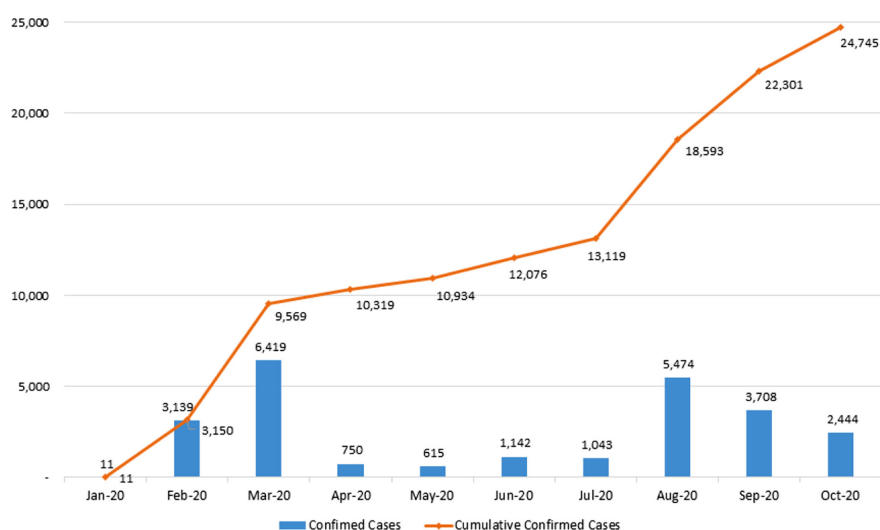


Fig. 1. Monthly and cumulative number of confirmed cases(excluding imported cases).

### 3. Data

The third data set for the number of COVID-19 confirmed cases was organized by recording the number of confirmed cases per day released by the government every day starting in January when the first confirmed case occurred. The COVID-19 data set used in this study was aggregated and reconstructed monthly. In this paper, we use two data sets-the “recyclable resource price survey” data set and the COVID-19 data set. The first dataset is data released monthly by the Korea Environment Corporation, showing prices for 23 items of 5 types waste (paper, plastic, glass, metal, etc.). The data set represent market prices by waste per 1kg unit in eight regions, including the capital area. In this paper, data for 15 major items out of 23 items for January to October 2020 and January to October 2019 are analyzed. Table A in the Appendix shows the average price of 16 items by region before and after COVID-19 outbreak. The second data set, COVID-19 data, set used in this study was recorded daily based on government publication.

### 4. Analysis and Results

#### 4.1. Correlation Analysis : The Relationship Between the Price (Won/kg) of Items and the Number of Confirmed Cases

A correlation analysis was performed on the number of confirmed persons and 15 items of 4 types waste (paper, plastic, glass, metal). Appendix Table B summarizes the results. In Table B, the probability of significance for “Glass Bottle (White, Brown, Blue-Green)” was greater than 0.05, but was not significant. The significance probability of all the remaining items are less than 0.05, which are significant, and the values of the correlation coefficient are negative. This indicates that the waste price excluding Glass Bottle and the number of confirmed cases are a negative correlation.

#### 4.2. T-test : Price (Won/kg) of Items for COVID-19 Outbreak

To find out the difference in the price of each item before (2019) and after (2020) COVID-19 outbreak, we analyze a T-test, and the results are shown in Table 1.

**Table 1.** The Results of T-test for Price (Won/kg) with Before and After COVID-19

Varialbe	t	df	p-value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		
						Lower	Upper	
Paper	Newspaper	12.268	104.496	0.000**	18.788	1.531	15.751	21.824
	Corrugated Paper	7.118	118.778	0.000**	10.15	1.426	7.327	12.973
Plastic	PE FLAKE	18.637	88.472	0.000**	79.45	4.263	70.979	87.921
	PP FLAKE	14.707	100.526	0.000**	57.163	3.887	49.452	64.873
	PE PELLETT	18.29	101.647	0.000**	75.788	4.144	67.568	84.007
	PP PELLETT	11.459	120.079	0.000**	40.425	3.528	33.44	47.41
	Compression PET	5.871	93.912	0.000**	25.4	4.326	16.81	33.99
	Compression PE	16.408	95.349	0.000**	71.875	4.381	63.179	80.571
	Compression PP	14.225	86.21	0.000**	57.05	4.011	49.077	65.023
Glass	Glass Bottle (White)	-2.307	158	0.022*	-1.013	0.439	-1.879	-0.146
	Glass Bottle (Brown)	-1.283	158	0.201	-0.563	0.438	-1.428	0.303
	Glass Bottle (Blue-Green)	-0.64	152.377	0.523	-0.138	0.215	-0.562	0.287
Metal	Scrap Iron	13.958	158	0.000**	48.225	3.455	41.401	55.049
	Iron Can	16.514	158	0.000**	36.688	2.222	32.3	41.075
	Aluminum Can	15.678	120.756	0.000**	106.425	6.788	92.985	119.865

In all items except for Glass Bottle (Brown, Blue-Green), the significance probability value was much lower than 0.05, indicating that there was a difference in the price of recycling resource before and after COVID-19 outbreak. The mean differences of plastics were at least 25.4 and at most 75.788, and were significantly higher than other items. Through this, we can confirm that the price of items excluding Glass Bottle is affected by COVID-19 and is unstable.

**4.3. T-test : Price(Won/kg) of Items by Regions for COVID-19 Outbreak**

To find out the difference in the price of each item before (2019) and after (2020) COVID-19 outbreak, we analyze T-test by regions, and the results are shown in Table C. Table 2 summarizes the results.

Newspapers, FLAKE (PE, PP), PELLET (PE, PP), Compression (PE, PP), Scrap Iron, Iron Can, and Aluminum Can show differences in the price before and after COVID-19 in all regions.

Corrugated Paper shows that there is a difference in price before and after COVID-19 outbreak in regions excluding Gyeongbuk and Chungbuk. Compression PET shows that there is a difference in price before and

after COVID-19 outbreak in Gangwon, Gyeongbuk, Jeonbuk, and Chungbuk.

Glass Bottle (White) appears to have a difference in price before and after COVID-19 outbreak in the capital area, Gyeongbuk, Jeonbuk, Chungnam, and Chungbuk. Glass Bottle (Brown) appears to have a difference in price before and after COVID-19 outbreak in Gangwon, Jeonbuk, Chungnam, and Chungbuk. Glass Bottle (Blue-Green) appears to have a difference in price before and after COVID-19 outbreak in the metropolitan area, Gangwon, and Chungbuk.

**4.4. Analysis of Variance (ANOVA) : Price (Won/kg) of Items in Regions for COVID-19 Outbreak**

We analyze ANOVA to determine if there is a difference in the price of each item in eight regions, before (2019) and after (2020) the COVID-19 outbreak. Table D in the Appendix gives the results, and Table 3 summarizes Table D on a p-value basis.

Before the outbreak of COVID-19, the prices of items excluding Newspaper and Iron have a difference in price before and after COVID-19 outbreak by regions. After COVID-19 outbreak, the prices of 9 items—newspaper, corrugated paper, PELLET (PE, PP), Glass

**Table 2.** Summary p-value of T-test (for Table C)

Items	Capital	Gangwon	Gyeongnam	Gyeongbuk	Jeonnam	Jeonbuk	Chungnam	Chungbuk
Newspaper	0.002**	0.000**	0.001**	0.002**	0.000**	0.000**	0.002**	0.000*
Corrugated Paper	0.030*	0.000**	0.007**		0.001*	0.008**	0.002**	
PE FLAKE	0.000**	0.000**	0.000**	0.000**	0.000*	0.000**	0.000**	0.000**
PP FLAKE	0.000**	0.001**	0.000**	0.000**	0.000**	0.001**	0.000**	0.001**
PE PELLET	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
PP PELLET	0.000**	0.005**	0.000**	0.000**	0.000**	0.001**	0.000**	0.000**
Compression PET		0.029*		0.021*		0.029*		0.029*
Compression PE	0.000**	0.000*	0.000**	0.002*	0.000**	0.000**	0.000**	0.000**
Compression PP	0.000**	0.000**	0.000**	0.003**	0.000**	0.003**	0.000**	0.001**
Glass Bottle (White)	0.000**			0.001**		0.000**	0.000**	0.000**
Glass Bottle (Brown)		0.037*				0.022*	0.005**	0.000**
Glass Bottle (Blue-Green)	0.000**	0.015*						0.000**
Scrap Iron	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.002**	0.000**
Iron Can	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Aluminum Can	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**

**Table 3.** Summary p-value of ANOVA (for Table D)

	Items	p-value	
		Before COVID-19	After COVID-19
Paper	Newspaper	0.203	0.000**
	Corrugated Paper	0.000**	0.000**
Plastic	PE FLAKE	0.000**	0.986
	PP FLAKE	0.000**	0.407
	PE PELLETT	0.000**	0.002**
	PP PELLETT	0.000**	0.000**
	Compression PET	0.000**	0.289
	Compression PET	0.000**	0.623
	Compression PP	0.000**	0.231
Glass Bottle	Glass Bottle (White)	0.000**	0.000**
	Glass Bottle (Brown)	0.000**	0.000**
	Glass Bottle (Blue-Green)	0.000**	0.000**
	Scrap Iron	0.000**	0.004**
Metal	Iron can	0.885	0.502
	Aluminum Can	0.000**	0.006**

bottle (White, Brown, Blue-Green), scrap iron, and aluminum—have a difference by region.

## 5. Conclusions

In this paper, we addressed the hypothesis that COVID-19 triggers a single-use plastic pandemic and that this will affect the shaping of market prices for recycled resources. In particular, the goal was to discuss that recycling is difficult and the price fluctuations of overproduced plastic waste are more sensitive.

As a result of Table 1, the COVID-19 outbreak affected the price fluctuation of items excluding Glass Bottles (Brown, Blue-Green), and prices fell after the COVID-19 outbreak. The mean difference between plastics before and after COVID-19 outbreak was 39.867 at a minimum and 78.975 at a maximum, which explains that the amount fluctuations are very large compared to other items.

Table 2 shows that the COVID-19 outbreak is the price of 10 items—Newspaper, FLAKE (PE, PP), PELLET (PE, PP), Compression (PE, PP), Scrap Iron, Iron Can, Aluminum Can—all regions Influenced by.

As a result of Table 3, it can be seen that the prices of 14 items before COVID-19 outbreak differ by region,

and the prices of 9 items after COVID-19 outbreak vary by region. In order to analyze the cause of the decline in the market price of recyclable resources by region after the COVID-19 outbreak, detailed data on the amount of waste produced and recycled by each region are needed.

Based on the preceding results, we have demonstrated that the COVID-19 outbreak has affected the price of the domestic recyclable resource market. This is evidence supporting the economic difficulties of domestic recycling companies. The Ministry of Environment restricts import and export regulations to exhaust domestic demand for recycled raw materials and implements a waste price indexation system, but this is only a short-term solution.

Jeong<sup>[12]</sup> investigated the current status of EPR implemented in the EU and analyzed the limitations to derive implications for the EPR in Korea. Han<sup>[13]</sup> argued that it is important to maintain the overall recycling process through reinforcement of EPR, reinforcement of separate discharge supervision, and support for recycling companies, not just entrusting the price of recyclable waste to the market. The results of this paper are evidence to support such prior studies. In order to solve the plastic pandemic from a long-term perspective, companies must voluntarily participate in the entire process from plastic collection to processing and recycling. In addition, companies should conduct research on post-consumer recycled material (PCR) materials, encourage and support R&D related to eco-friendly packaging to corporate sustainability management for resource recycling.

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## Appendix

Table A. Comparison of recyclable resource price by regions for before and after COVID-19 outbreak

Items	Capital Region		Gyeongnam		Gyeongbuk		Jeonnam		Jeonbuk		Chungnam		Chungbuk			
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After		
Newspaper	94.60	79.10	91.80	69.80	89.80	71.80	100.20	77.40	99.80	73.40	86.80	68.70	92.50	79.50	90.60	76.10
Corrugated	77.10	67.40	73.70	57.40	65.50	57.90	69.20	64.10	81.90	60.60	68.60	59.70	74.80	61.40	57.10	58.20
PE FLAKE	580.80	501.00	568.80	497.40	583.90	507.20	591.30	507.70	583.40	497.50	578.30	497.20	578.10	493.70	567.20	494.50
PP FLAKE	512.00	453.00	489.50	453.70	518.50	466.00	521.60	466.10	524.80	457.70	517.80	452.50	504.50	432.80	500.20	449.80
PE PELLET	771.30	691.20	756.20	705.30	778.40	694.50	768.60	660.80	742.20	652.70	751.90	692.10	768.20	698.50	756.80	692.20
PP PELLET	685.20	634.30	650.30	622.10	659.00	601.70	674.20	631.80	637.60	585.30	659.80	639.90	657.20	625.00	647.50	607.30
Compression PET	285.70	253.70	253.90	225.60	276.30	256.50	255.40	222.40	254.40	231.50	256.80	227.90	256.50	239.70	265.50	244.00
Compression PE	393.70	304.70	370.60	293.60	396.40	312.80	387.00	327.00	369.60	298.50	364.70	304.00	374.20	302.90	375.50	313.20
Compression PP	343.50	283.50	335.00	271.10	341.50	276.30	349.40	305.60	325.60	272.60	334.70	285.30	332.00	263.00	335.40	283.30
Glass Bottle (White)	57.00	57.80	52.00	52.20	56.00	56.00	57.30	58.00	61.00	62.00	59.00	61.00	59.00	59.80	56.20	58.80
Glass Bottle (Brown)	36.00	35.90	29.00	30.20	37.00	36.90	33.00	32.80	34.00	34.00	36.00	36.80	37.00	37.60	30.10	32.40
Glass Bottle (Blue-Green)	22.60	21.00	22.50	23.00	25.00	25.20	24.00	24.80	23.00	23.00	22.00	21.80	25.00	25.00	22.60	24.00
Scrap Iron	236.50	194.30	237.00	182.20	227.70	166.00	230.80	175.10	237.00	193.90	233.40	182.60	215.90	184.00	203.50	157.90
Iron Can	185.20	148.50	181.80	144.80	185.20	147.00	189.40	155.90	185.90	154.70	180.80	148.00	186.00	145.50	186.80	143.20
Aluminum Can	1059.10	966.90	1049.60	959.30	1007.80	896.50	1006.30	913.60	1040.00	958.30	1073.50	950.00	1069.80	926.60	1020.60	904.10

**Table B.** Results of correlation analysis between recyclable resource price and the number of confirmed cases

Items	Confirmed Cases	Newspaper	Corrugated Paper	PE FLAKE	PP FLAKE	PE PELLET	PP PELLET	Compression PET	Compression PE	Compression PP	Glass Bottle (White)	Glass Bottle (Brown)	Glass Bottle (Blue-Green)	Scrap Iron	Iron Can	Aluminum Can
Confirmed Cases	1.000															
Newspaper	-.433**	1.000														
Paper	-.290**	.814**	1.000													
PE FLAKE	-.527**	.573**	.331**	1.000												
PP FLAKE	-.503**	.507**	.277**	.969**	1.000											
PE PELLET	-.537**	.565**	.301**	.929**	.862**	1.000										
PP PELLET	-.464**	.466**	.277**	.828**	.781**	.856**	1.000									
Plastic	-.184*	.208**	-.017	.772**	.764**	.749**	.670**	1.000								
Compression PET									1.000							
Compression PE	-.517**	.534**	.271**	.969**	.941**	.916**	.850**	.806**	1.000							
Compression PP	-.490**	.483**	.227**	.958**	.948**	.876**	.860**	.787**	.974**	1.000						
Glass Bottle (White)	0.136	-0.06	0.087	-.181*	-0.123	-.326**	-.231**	-.180*	-.205**	-.213**	1.000					
Glass Bottle (Brown)	0.074	-0.072	0.094	-0.06	-0.041	-0.019	0.045	0.084	-0.059	-0.132	.555**	1.000				
Glass Bottle (Blue-Green)	0.019	-0.026	-0.124	0.006	0.004	0.017	-0.124	0.006	0.077	-0.019	-0.015	.225**	1.000			
Scrap Iron	-.393**	.742**	.744**	.564**	.475**	.535**	.441**	.167*	.487**	.441**	-0.079	-0.028	-.216**	1.000		
Iron Can	-.393**	.796**	.664**	.609**	.525**	.581**	.446**	.200*	.566**	.512**	-0.093	-0.094	-0.039	.898**	1.000	
Aluminum Can	-.422**	.546**	.454**	.819**	.753**	.772**	.692**	.588**	.759**	.761**	-0.123	-0.078	-.279**	.694**	.673**	1.000



**Table C.** Results of T-test by regions; independent variable-recyclable resource price, dependent variable-COVID-19 outbreak

Region	Item	t	df	p-value	Region	Item	t	df	p-value
Capital Region	Newspaper	4.073	11.897	0.002	Gangwon-do	Newspaper	5.464	10.594	0.000
	Corrugated Paper	2.358	18	0.030		Corrugated Paper	4.482	15.285	0.000
	PE FLAKE	6.413	9.098	0.000		PE FLAKE	5.844	9.034	0.000
	PP FLAKE	5.701	9.613	0.000		PP FLAKE	4.513	9.021	0.001
	PE PELLET	8.388	9.925	0.000		PE PELLET	6.315	10.797	0.000
	PP PELLET	5.35	9.327	0.000		PP PELLET	3.7	9.007	0.005
	Compression PET	2.234	9.053	0.052		Compression PET	2.597	9.008	0.029
	Compression PE	7.105	10.554	0.000		Compression PE	7.049	9.024	0.000
	Compression PP	5.546	9.604	0.000		Compression PP	6.378	9	0.000
	Glass Bottle (White)	-6	9	0.000		Glass Bottle (White)	-0.408	9	0.693
	Glass Bottle (Brown)	1	9	0.343		Glass Bottle (Brown)	-2.449	9	0.037
	Glass Bottle (Blue-Green)	6	9	0.000		Glass Bottle (Blue-Green)	-3	9	0.015
	Scrap Iron	4.865	18	0.000		Scrap Iron	6.204	18	0.000
	Iron Can	5.931	18	0.000		Iron Can	6.33	18	0.000
Aluminum Can	7.172	9.575	0.000	Aluminum Can	7.396	9.679	0.000		
Gyeongsangnam-do	Newspaper	4.639	9.626	0.001	Gyeongsangbuk-do	Newspaper	3.964	10.766	0.002
	Corrugated Paper	3.065	18	0.007		Corrugated Paper	1.623	18	0.122
	PE FLAKE	6.595	9.89	0.000		PE FLAKE	6.616	9.405	0.000
	PP FLAKE	5.29	9.438	0.000		PP FLAKE	5.98	9.551	0.000
	PE PELLET	7.203	9.803	0.000		PE PELLET	8.499	9.314	0.000
	PP PELLET	5.584	9.718	0.000		PP PELLET	6.228	9.549	0.000
	Compression PET	1.673	9.296	0.128		Compression PET	2.776	9.052	0.021
	Compression PE	5.836	9.132	0.000		Compression PE	4.208	9.024	0.002
	Compression PP	5.914	9.12	0.000		Compression PP	4.137	9.033	0.003
	Glass Bottle (White)	0.429	18	0.673		Glass Bottle (White)	-4.583	9	0.001
	Glass Bottle (Brown)	-1.5	9	0.168		Glass Bottle (Brown)	0.557	9	0.591
	Glass Bottle (Blue-Green)	5.456	18	0.000		Glass Bottle (Blue-Green)	-2.058	14.737	0.058
	Scrap Iron	5.487	18	0.000		Scrap Iron	5.681	18	0.000
	Iron Can	6.338	9.909	0.000		Iron Can	4.779	18	0.000
Aluminum Can	4.639	9.626	0.001	Aluminum Can	5.397	11.209	0.000		

Table C. Continued

Region	Item	t	df	p-value	Region	Item	t	df	p-value
Jeollanam-do	Newspaper	5.316	9.2	0.000	Jeollabuk-do	Newspaper	5.983	9.179	0.000
	Corrugated Paper	4.87	9.259	0.001		Corrugated Paper	2.958	18	0.008
	PE FLAKE	6.765	9.331	0.000		PE FLAKE	6.841	9.12	0.000
	PP FLAKE	6.34	9.18	0.000		PP FLAKE	5.234	9.038	0.001
	PE PELLET	8.074	10.148	0.000		PE PELLET	7.316	9.338	0.000
	PP PELLET	9.978	12.15	0.000		PP PELLET	5.141	9.293	0.001
	Compression PET	2.214	9.004	0.054		Compression PET	2.589	9.028	0.029
	Compression PE	7.456	9.319	0.000		Compression PE	5.557	9.004	0.000
	Compression PP	5.729	9.223	0.000		Compression PP	3.975	9.003	0.003
	Glass Bottle (White)	-	-	1.000		Glass Bottle (White)	-6	9	0.000
	Glass Bottle (Brown)	-	-	1.000		Glass Bottle (Brown)	-2.753	9	0.022
	Glass Bottle (Blue-Green)	-	-	1.000		Glass Bottle (Blue-Green)	1.5	9	0.168
	Scrap Iron	5.457	18	0.000		Scrap Iron	7.017	18	0.000
Iron Can	4.99	18	0.000	Iron Can	6.165	18	0.000		
Aluminum Can	5.729	11.59	0.000	Aluminum Can	8.134	12.011	0.000		
Chungcheongnam-do	Newspaper	3.521	18	0.002	Chungcheongbuk-do	Newspaper	5.278	10.509	0.000
	Corrugated Paper	3.886	11.994	0.002		Corrugated Paper	-0.829	18	0.418
	PE FLAKE	6.764	9.568	0.000		PE FLAKE	5.974	9.45	0.000
	PP FLAKE	6.135	9.546	0.000		PP FLAKE	4.998	9.222	0.001
	PE PELLET	7.493	10.587	0.000		PE PELLET	6.639	10.904	0.000
	PP PELLET	6.555	11.239	0.000		PP PELLET	5.253	9.265	0.000
	Compression PET	1.296	9.003	0.227		Compression PET	2.581	9.083	0.029
	Compression PE	6.317	9.332	0.000		Compression PE	5.419	9.022	0.000
	Compression PP	5.464	9.091	0.000		Compression PP	4.982	9.026	0.001
	Glass Bottle (White)	-6	9	0.000		Glass Bottle (White)	-6.789	11.436	0.000
	Glass Bottle (Brown)	-3.674	9	0.005		Glass Bottle (Brown)	-8.076	11.482	0.000
	Glass Bottle (Blue-Green)	-	-	1.000		Glass Bottle (Blue-Green)	-8.573	9	0.000
	Scrap Iron	3.621	18	0.002		Scrap Iron	8.364	11.989	0.000
Iron Can	6.21	18	0.000	Iron Can	6.536	18	0.000		
Aluminum Can	8.027	10.085	0.000	Aluminum Can	5.711	10.218	0.000		

**Table D.** Results of ANOVA by COVID-19 outbreak; independent variable-regions, dependent variable-recyclable resource price

Before COVID-19							After COVID-19						
Items	Source of Variation	Sum of Squares	df	Mean Square	F	p-value	Items	Source of Variation	Sum of Squares	df	Mean Square	F	p-value
Newspaper	Between Groups	1562.188	7	223.17	1.441	0.203	Newspaper	Between Groups	1213.55	7	173.364	13.956	0.000
	Within Groups	11151.3	72	154.879				Within Groups	894.4	72	12.422		
	Total	12713.49	79					Total	2107.95	79			
Corrugated Paper	Between Groups	4102.088	7	586.012	7.015	0.000	Corrugated Paper	Between Groups	827.788	7	118.255	4.469	0.000
	Within Groups	6014.9	72	83.54				Within Groups	1905.1	72	26.46		
	Total	10116.99	79					Total	2732.888	79			
PE FLAKE	Between Groups	4424.75	7	632.107	21.743	0.000	PE FLAKE	Between Groups	2011.15	7	287.307	0.195	0.986
	Within Groups	2093.2	72	29.072				Within Groups	106320.8	72	1476.678		
	Total	6517.95	79					Total	108332	79			
PP FLAKE	Between Groups	10273.29	7	1467.612	77.203	0.000	PP FLAKE	Between Groups	7745	7	1106.429	1.047	0.407
	Within Groups	1368.7	72	19.01				Within Groups	76088.8	72	1056.789		
	Total	11641.99	79					Total	83833.8	79			
PE PELLETT	Between Groups	9914.6	7	1416.371	25.855	0.000	PE PELLETT	Between Groups	24475.49	7	3496.498	3.587	0.002
	Within Groups	3944.2	72	54.781				Within Groups	70182.9	72	974.763		
	Total	13858.8	79					Total	94658.39	79			
PP PELLETT	Between Groups	15870.8	7	2267.257	120.439	0.000	PP PELLETT	Between Groups	24495.75	7	3499.393	6.823	0.000
	Within Groups	1355.4	72	18.825				Within Groups	36929.8	72	512.914		
	Total	17226.2	79					Total	61425.55	79			
Compression PET	Between Groups	9936.187	7	1419.455	291.586	0.000	Compression PET	Between Groups	11680.99	7	1668.712	1.247	0.289
	Within Groups	350.5	72	4.868				Within Groups	96330.9	72	1337.929		
	Total	10286.69	79					Total	108011.9	79			
Compression PET	Between Groups	9815.387	7	1402.198	60.472	0.000	Compression PET	Between Groups	7549.287	7	1078.47	0.759	0.623
	Within Groups	1669.5	72	23.187				Within Groups	102239.1	72	1419.988		
	Total	11484.89	79					Total	109788.4	79			
Compression PP	Between Groups	3829.187	7	547.027	63.907	0.000	Compression PP	Between Groups	11431.89	7	1633.127	1.371	0.231
	Within Groups	616.3	72	8.56				Within Groups	85782.5	72	1191.424		
	Total	4445.487	79					Total	97214.39	79			

**Table D.** Continued

		Before COVID-19						After COVID-19					
Glass Bottle (White)	Between Groups	504.487	7	72.07	378.76	0.000	Glass Bottle (White)	Between Groups	662.4	7	94.629	187.177	0.000
	Within Groups	13.7	72	0.19				Within Groups	36.4	72	0.506		
	Total	518.187	79					Total	698.8	79			
Glass Bottle (Brown)	Between Groups	672.087	7	96.012	7681	0.000	Glass Bottle (Brown)	Between Groups	486.15	7	69.45	90.26	0.000
	Within Groups	0.9	72	0.013				Within Groups	55.4	72	0.769		
	Total	672.987	79					Total	541.55	79			
Glass Bottle (Blue-Green)	Between Groups	96.587	7	13.798	46.642	0.000	Glass Bottle (Blue-Green)	Between Groups	167.15	7	23.879	252.832	0.000
	Within Groups	21.3	72	0.296				Within Groups	6.8	72	0.094		
	Total	117.887	79					Total	173.95	79			
Scrap Iron	Between Groups	10173.95	7	1453.421	5.344	0.000	Scrap Iron	Between Groups	11317.2	7	1616.743	3.387	0.004
	Within Groups	19582	72	271.972				Within Groups	34366.8	72	477.317		
	Total	29755.95	79					Total	45684	79			
Iron can	Between Groups	522.187	7	74.598	0.423	0.885	Iron can	Between Groups	1464.6	7	209.229	0.912	0.502
	Within Groups	12687.3	72	176.213				Within Groups	16519.2	72	229.433		
	Total	13209.49	79					Total	17983.8	79			
Aluminum Can	Between Groups	50105.39	7	7157.912	35.199	0.000	Aluminum Can	Between Groups	53388.09	7	7626.87	3.172	0.006
	Within Groups	14641.5	72	203.354				Within Groups	173097.3	72	2404.129		
	Total	64746.89	79					Total	226485.4	79			