The Determinants of Waste Agricultural Plastics Generation in the Republic of Korea

Chang YJ (Professor, Inje University, ROK)
Kim GS (Professor, Hoseo University, ROK)[1)]
Kim GY (Professor, Hansung University, ROK)

1. Introduction

Modern farming takes advantage of much plastics and thus inevitably waste agricultural plastics (wap) are generated very much. Vinyl-house horticulture and insulated rice seedbed preparing are practiced nationwide and in the year of 2015 approximately 320 thousand tons of wap are generated in total, which has remained almost the same through the last decade. By kind the most dominant one is mulching LDPE (approximately 40%) followed by HDPE (35%) and Vinyl-house LDPE (20%). Collection rate has stagnated at a little less than 60%. So collection and proper treatment of wap, including recycling, is one of a big social concern in Korea.

Waste agricultural plastics is one of municipal solid waste in the ROK, the final treatment of which is the responsibility of so-called basic administrative units. (like eup, myon, dong)[2)] So in principle basic administrative units have to collect and recycle or do final disposal (landfilling and incineration). However, because of market failure in collection and treatment, Korea Environmental Public Corporation (KEPCO) intervenes in markets by establishing a collection and treatment network. KEPCO receives wap from designated private collectors and treat by itself or sell the collected wap to private treatment companies. To have this whole system work, KEPCO subsidizes farmers through designated private collectors

1) Corresponding Author : gsgim@hoseo.edu
2) This does not mean that farmers have no legal problems with just leaving out wap in the field. They are legally prohibited from disposing waste improperly.

for bringing wap to community collection point. Then designated private collectors transport the collected wap to KEPCO-operated storage area. On the other hand KEPCO has once subsidized private treatment companies to alleviate the accumulation of untreated wap. Of course the market system encompasses all these KEPCO network. Thus market transactions bypassing this KEPCO network are always possible. For example vinyl-house wap may be picked up by private companies directly and recycled or sold to final treatment companies.

Vinyl-house waste cover-plastics are relatively clean and then well collected and almost recycled. However, mulching LDPE and HDPE waste plastics, which occupies 76% of total 322,964 tons generated in 2015, would be a problem if left intact. Un-collected and improperly treated waste plastics is detrimental to the environment and also undermines agricultural land productivity. Governments at various levels have used various subsidies to promote complete collection and proper treatment of wap. However, they have not been flexible enough to tailor these incentive measures to changing environment like demographic trend in agricultural regions and price fluctuations in recycled products and petroleum markets, etc. The result is still insufficient collection on the one hand and over-capacity for treatment on the other hand. The overall treatment capacity has been once short. At that time KEPCO subsidized private treatment firms to enhance the overall capacity. Now the situation has changed. Private treatment firms have to buy wap from KEPCO through a competitive auction. One important policy question is what the optimal combination of public and private treatment capacity is. Estimating the determinants of wap generation and then making an accurate prediction of generation and collection is a first step to answering that important question.

The paper proceeds as follows. In the next section we describe the data to be used and explains the methodology for the estimation. In the third section we provides with the empirical results and discusses its policy implication. Lastly, we make some concluding remarks.

2. Data and Methodology

Panel data covering wap generation in 9 regions across 12 years (2004 through 2015) are regressed on potential determinants like sizes of paddy, field and vinyl house farming as follows.

$$PE \quad \beta \; + \beta_1 paddy + \beta_2 field + \beta_3 House + \epsilon \qquad (*)$$

The following <Table1> is the summary statistics for our data.

<Table1. Summary Statistics>

	MPE	paddy	field	House
mean	26,289.56	106,379.23	4,439.76	80,904.06
stand. dev.	12,146.60	61,947.29	4,729.77	27,252.56
min.	1,319.00	18.00	0.00	52,100.00
max.	59,634.00	219,337.00	18,287.00	152,095.00

note : MPE, paddy, field, House stands for mulching plastics generation, size of paddy field, size of dry field, size of vinyl house, respectively.

We have checked first so-called poolability of time-series and cross-sectional data. Based on F-statistic (0.42652) we could reject the null hypothesis at 5% level that the coefficients are not stable. Next we have checked autocorrelation in error terms. Breusch-Godfrey/ Wooldridge test has detected the presence of autocorrelation. So we have added the lag term for dependent variable to set our final regression model as follows.

$$MPE = \beta_0 + \beta_1 paddy + \beta_2 field + \beta_3 House + \beta_4 lag(MPE) + \epsilon \qquad (**)$$

By Breusch-Godfrey/ Wooldridge test we have identified that there is no autocorrelation in error terms. (chi-square statistic=2.1548) Also, by Honda Test we have known that there is no individual effect (standard normal statistic=0.024989), but there is time effect (standard normal statistic=4.6167) Finally by Hausman test we have chosen random effects model (chi-square statistic=5.6698)

3. Empirical Results and Discussion

The regression results are reported in the following <Table2>. House (size of vinyl house farming) and lag(MPE) are significant at 5%, 1% level, respectively. The effect of lag(MPE) is statistically significant and moreover it is strong. Almost 67 percent of wap generated in the last year is again generated this year in inertia. Notice that the effect of field (size of dry field) is almost the same as the one of House (size of vinyl house farming), but it is not statistically significant.

<Table2. Regression Result>

	coefficient	standard error	t-value	P-value
intercept	574.9600	1901.1000	0.3024	0.7630
paddy	0.0189	0.0116	1.6276	0.1070
field	0.0893	0.1403	0.6361	0.5263
House	0.0737	0.0302	2.4409	0.0165 *
lag(MPE)	0.6715	0.0749	8.9676	0.0000***

note : *,**,*** stands for 10%, 5%, 1% significance level, respectively.

Based on this estimation, we have forecasted the future MPE. In order to do that, we needed to estimate the future values of explanatory variables first. For this purpose, we have regressed each of explanatory variables on respective previous values and time. We have used the estimated value of one coefficient as its future value if it is statistically significant. In case we didn't get statistical significance we have just averaged the previous 5 years' values to use as each of its upfront 5 years' future values. Now we have put the estimated values of explanatory variables into the estimated equation (**) to get the future values of MPE, the 95% confidence interval for which is summarized in the following <Table3>.

<Table3. 95% Confidence Interval for Prediction of MPE>

year	lower bound	point estimate	upper bound
2016	221,466.6	247,363.4	273,260.2
2017	224,616.4	247,827.1	271,037.8
2018	226,404.7	248,955.6	271,506.6
2019	190,964.2	232,544.9	274,125.6
2020	174,274.4	209,293.8	244,313.2

As you can see, the generation of MPE is predicted to decline after 2019. It is predicted to stabilize around 200 thousands ton per year since then. Assuming current treatment capacity (private 100 thousand and public 80 thousand annually) and rate of collection (approximately 60%) the current treatment capacity seems to be able to handle this 200 thousands ton safely.

4. Concluding Remarks

In contrast to the case of the ROK, Japan and Taiwan define wap as an industrial waste. So farmers are responsible for proper treatment of wap. In both countries central government doesn't take such an active role as in Korea. In other words collection and treatment are made basically by market mechanism. Farmers buy the treatment service at a positive price. Collection rates are almost 100%. To have this market mechanism work more smoothely, Taiwanese government compensate farmers for sorting and bringing waste plastic containers to treatment firms, but not for general wap. Japanese government too compensate farmers for bringing waste plastics to collection points. Under the present system, Korean government (KEPCO in fact) has always to care about optimal subsidies for collecting, transporting and treating wap. In light of Japanese and Taiwanese experiences, Korea also needs to strengthen a "polluter pays" principle and have collection, transportation and treatment of wap made more voluntarily by stakeholder.

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