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Determinants of recycling common types of plastic product waste in environmental horticulture industry: The case of Georgia

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ABSTRACT

Environmental horticulture firms provide a variety of commercial/residential landscape products and services encompassing ornamental plant production, design, installation, and maintenance. The companies generate tons of waste including plastic containers, trays, and greenhouse/field covers, creating the need to reduce and utilize plastic waste. Based on survey data collected in Georgia in 2013, this paper investigates determinants of the environmental horticulture firms' recycling decision (plastic containers, flats, and greenhouse poly). Our findings indicate that the decision to discard vs. recycle plastic containers, flats, and greenhouse poly is significantly influenced by firm scope, size, location, and partnership with recycling providers, as well as whether recycling providers offer additional waste pickup services. Insights from this study are of use to local governments and environmental organizations interested in increasing horticultural firm participation in recycling programs and lowering the volume of plastic destined for landfills.

1. Introduction

Environmental horticulture firms provide a variety of products and services to commercial/residential users encompassing the design, installation, and maintenance of landscapes. One of the greatest problems facing horticulture firms is the huge amount of solid waste generated during the production and service process (Antón et al., 2005). Organic horticultural waste such as tree trunks, branches, plant parts, and trimmings (Xin and Geng, 2011) is often composted and utilized by residential and commercial users. Plastics play a substantial role in horticulture (Hemphill, 1993). However, the disposal of plastic waste including plastic containers, trays, flats, greenhouse covers, and field covers is much more complex. Plastic waste in horticulture has become a significant contributor to solid waste disposal problems, especially firms that are heavy users of plastic products. The Environmental Protection Agency (EPA) estimates that plastic accounts for about 12% total solid waste. The majority of plastic waste originates in households, but the total figure includes plastic waste from all sources including environmental horticulture (Perry Lawton, 2009). Some estimate that four percent of total plastics is consumed by agriculture (i.e., both agriculture and horticulture sectors because the figures do not distinguish between them) in the United States annually (Briassoulis et al., 2013a,b), while the agriculture consumes two percent of plastics in Europe. Although the exact volume of plastic waste generated by environmental horticulture in just about any country is not known, the redirection of any volume of plastic waste away from landfills to recycling has direct benefits to the environment as well as society at large. Consequently, a study like this one, based on primary data, provides additional insights about the horticultural plastic use.

Environmental concern for horticultural plastics disposal in landfills or incinerators (Hartz et al., 1996), difficulties in finding new landfill sites, and restrictions on incineration are forcing the development of more environmentally acceptable alternatives such as recycling (Hemphill, 1993; Antón et al., 2005; Missouri Botanical Garden, 2008; Briassoulis et al., 2013a,b). Among the available options, recycling seems to be the most promising. Although a large portion of horticultural firms recycles unneeded materials, the recycling process varies by specific materials and firms (GGIA, 2014a,b). Therefore, understanding determinants of recycling activities is of crucial importance in the environmental horticultural industry to enhance firms' recycling performance.

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Based on survey data collected from environmental horticulture firms in Georgia in 2013, the primary focus of the current study is to examine the relationship between selected firm features and decisions to recycle commonly used plastic products. Specifically, this study investigates factors that influence environmental horticulture firms' recycling decision regarding plastic containers, flats, and greenhouse poly. The study offers local government and sustainable development organizations useful knowledge for designing and implementing new or enhancing the existing recycling programs in the environmental horticultural area. The gained insights can be used to lower landfill burdens by enhancing environmental horticultural firm participation in plastic waste recycling.

2. Background of plastic waste recycling in the environmental horticultural industry

Food and plant production is very competitive and growers are under constant pressure to use resources efficiently to remain economically viable (Torrellas et al., 2012). Plastic materials, due to their low cost and high performance, have been widely used in various forms and shapes in horticulture. Plastic pots, containers, trays, and flats have been used extensively in environmental horticulture and landscaping. As such the sector creates a well-defined plastic waste stream although, admittedly, with a relatively small volume of waste.

While plastic containers contribute to the competitiveness of environmental horticulture, these items represent a challenge in disposal (Botts, 2007). Attributes that make plastic materials highly desirable in production and landscape services (Hemphill, 1993; Cameron, 2009) become significant flaws. Their light weight and resistance to biodegradation (Bai and Sutanto, 2002) are responsible for their persistence in the environment, while making them bulky to handle and transport for waste management companies. Thus, plastic waste from the environmental horticulture sector is discarded in landfills. Reduction of plastic waste disposed to landfills will make environmental horticulture more sustainable (Cameron, 2009). An added benefit is improvement of the visual appearance of a landscape that is not littered with pieces of plastic film, such as can be seen in some areas of Israel, Spain (Montero et al., 2012), and other countries (Briassoulis et al., 2013a,b).

Several plastic types are widely used in the environmental horticulture industry including low-density polyethylene (LDPE), high-density polyethylene (HDPE), polypropylene (PP), and high-impact polystyrene (PS). HDPE is used in nursery containers especially for growing trees and shrubs (Cameron, 2009). LDPE, because of its low cost, is employed extensively for greenhouse covers. PP resists breakage, and being lightweight, is commonly used in the production of potted flowering and bedding plants. Flats and plug trays are commonly molded from PS. The variety of plastic types and uses has not been subject to standardization and requires substantial efforts to sort and store until a volume justifying shipment to a recycling facility is accumulated.

A hierarchy of plastic waste management includes waste minimization, waste reuse, and waste recovery, and treats landfill disposal as the lowest priority (Vilaplana and Karlsson, 2008). A lot has been written about re-using plastic containers in environmental horticulture (for example, Cameron, 2009), but a large problem is the need to clean and assure disease control in reused containers. In the United States, there have been initiatives to recycle plastic horticultural containers undertaken in individual states or urban areas. For example, New Jersey facilitates the collection of greenhouse plastic, while the Minnesota Nursery & Landscape Association developed a program to collect plastic (Cameron, 2009). In the Netherlands, a large producer of ornamental horticulture products, there have been efforts to develop effective plastic container sterilization methods due to fears of infecting the multi-billion domestic production with imported diseases (Santing, 2000). Efforts were undertaken to apply gamma irradiation to decontaminate plastic pots and other materials used in horticultural production. However, the use of gamma irradiation by domestic ornamental plant producers requires that pots be transported to a central facility for treatment and then back to the grower, adding costs. Although this method may be effective in overcoming the lack of plastic container standardization that limits reuse, there is no equipment that can reduce the labor costs of cleaning and sterilization. Consequently, pot cleaning can only be accomplished by homeowners or volunteers rather than large-scale commercial nurseries (Perry Lawton, 2009).

The limitations of reusing plastic containers, trays and flats as well as the greenhouse poly suggest recycling as the next preferred waste management option. Recycling involves energy recovery and material recycling (Vilaplana and Karlsson, 2008). Energy recovery uses plastic waste as fuel for energy production. Plastic waste from environmental horticulture is high in calorific content. In Spain, the valorization of plastic waste is a major technique to treat plastic waste. For example, greenhouse poly is incinerated in some areas to produce electricity (Antón et al., 2005; Montero et al., 2012). Incineration is also used in Scandinavian countries, but the contribution of environmental horticulture plastic waste in northern countries is relatively small. However, plastic materials are burned by farmers in the fields putting at risk human health and inflicting environmental damage (Briassoulis et al., 2013a,b).

Mechanical recycling is the process of reutilization of plastic waste in production of new plastic products. It entails cutting, washing, and drying followed by grinding. Washing may require a large effort because, for example, greenhouse covers are estimated to have 15–20% of their weight as dirt (Montero et al., 2012). Preferably, plastic waste from the environmental horticulture sector should be sorted by type because there is a market for recycled plastic that separately prices ground and flaked HDPE, LDPE, and PP, among others (Plastic News, 2015). But the program of the Missouri Botanical gardens skips sorting and simply grinds all collected horticultural plastic waste, producing an undifferentiated product used in manufacturing plastic landscape timbers (Cameron, 2009). The ultimate goal of mechanical recycling is to lower the waste of energy and the emission of greenhouse gases.

Sorting is labor-intensive and as such increases the cost of plastic waste to the party that undertakes this task. In environmental horticulture, firm sorting is facilitated by the type of production and produced ornamentals, but commonly, the firm performs such tasks without being compensated for employee time in the United States. Not surprisingly, recycling has been viewed as economically beneficial for developing countries (Duraiappah et al., 2002). In Europe, the reduction of plastic waste is forced by regulations. For example, the European Union Landfill Directive (1999) required member states to reduce their level of waste discarded in landfills to 35% by 2014 (Antón et al., 2005), while Incineration directive (2000) addressed burning of plastic (Briassoulis et al., 2012). The reduction of waste has effectively been implemented by requiring households to sort generated waste according to regulations set by each country's government. In other countries, for example the United States, such regulations regarding households are developed and implemented by municipal governments, but regulations applying to the environmental horticulture sector are different. As a result, the sorting in environmental horticulture firms varies widely, presumably because of local governmental concerns about the economic effect on individual growers.

Plastic waste generated by the environmental horticulture sector is large diversified and spatially dispersed. Spatial concentration of horticultural production facilitates recycling. For example, a company in northern Italy recycles horticultural plastic waste because in the area of the cities of Parma, Mantua, and Cremona, there is high concentration of horticultural production that uses greenhouse poly and similar plastic materials (Siwek et al., 2007). In the United States, the production and use of ornamental horticulture products is commonly in different areas. For example in the State of Georgia, environmental horticulture production is concentrated in non-metro counties, while the users of its products and services reside in the densely populated Atlanta metropolitan area. Moreover, because the regulatory process in the United States involves local governments, those governments need information prior to developing rules on recycling for a local plastic horticultural waste management system, including three major types of plastic waste generated by environmental horticulture firms, i.e., plastic containers, trays and flats, and greenhouse poly.

In Georgia, the environmental horticulture industry plays a significant role in the state economy. Ornamental and turf horticulture represented a value of almost $749 in 2012 (2012 Georgia Farm Gate Value Report). But, the environmental horticulture industry also includes landscaping, irrigation contractors, retail garden centers, and allied sales companies besides wholesale nursery growers and greenhouse operators, (GGIA, 2014a,b). In the process of providing a wide range of products and services, from ornamental plant production to landscape design, installation, and maintenance, due to the diverse business scope, it is not hard to understand that waste collection and recycling in the environmental horticulture sector is quite challenging. Although plastic waste can be recycled, only a small fraction can be reused in manufacturing new horticultural containers. Hemphill (1993) reports that new horticultural containers can be manufactured using up to 15% of recycled plastic, while up to 30% of recycled plastic is used in new agricultural films (Briassoulis et al., 2013a,b). In the United States, ground plastics are often used by other industries as a feedstock.

In Georgia, the collection and recycling of horticultural solid waste is managed by counties (Anon., 2011). Recycling centers operated by municipalities or private companies re-sell plastic materials to earn revenue from waste tipping fees. The horticultural sector is an important source of recyclable plastic. However, the specific nature of environmental horticulture firms and the plastic waste they generate is not recorded in detail. The volume of discarded recyclable plastic generated by horticultural firms is not well known for a number of reasons. For example, environmental horticulture plastic waste is often reported as agricultural plastic waste, similarly to many other countries (Briassoulis et al., 2013a,b). Plastic waste from horticulture production facilities is spatially concentrated, while that generated by service providers is more spatially dispersed. It is the solid plastic waste concentration in ornamental horticulture production regions and in densely populated user areas that offers opportunities for recycling because the large volume originates within a limited area. It is estimated that two-thirds of recycling is collection costs (EPA, 2003). In the absence of reliable figures on plastic waste discarded by environmental horticulture firms, we focus on examining factors behind the disposal decision of an environmental horticulture firm in search of opportunities to increase recycling. Presumably, knowledge of factors associated with the decision to recycle plastic trays, flats, and greenhouse poly (not only used by greenhouses) and the probability with which a change in a single factor is predicted to change the recycling decision may prompt modifications in county solid waste collection leading to a smaller volume of discarded waste.

3. Data and method

Traditional disposal methods of solid plastic waste such as landfilling or incineration cause environmental problems due to slow decay or toxic chemical release during combustion (Bai and Sutanto, 2002). Therefore, as discussed in the previous section, promotion of recycling among environmental horticulture firms is a promising alternative. Associated policies and programs need to be employed at a local level, therefore useful information about current recycling practices is highly desirable to formulate and implement suitable programs or modify existing waste collection schedules.

3.1. Survey implementation and data collection

A survey with a particular focus on environmental horticulture firms in Georgia was designed and implemented between January and March 2013. Questions regarding current recycling practices in the horticultural industry were a major part of the survey instrument. During the survey, participating horticultural firms were asked about their basic firm features, recycling practices, and their motivation toward recycling, while the person completing the questionnaire on behalf of the company, typically the owner or manager, also shared some socio-demographic characteristics. Data from this survey reveal the environmental horticulture firms' recycling behavior, providing unique insights to local and regional governments, as well as nonprofit organizations concerned about environmental protection and sustainable development.

The highly heterogeneous business activities of environmental horticulture firms constrain an easy identification of firms that should be included for data collection. The Georgia Green Industry Association (GGIA) encompasses a number of firms that are usually difficult to identify through licensing codes at registration offices in each county. Thus, the list of GGIA firm-members facilitated the initial identification of potential survey participants. After a review of the list provided by the GGIA, a number of addresses on the list were found to be associated with county extension offices or personnel, environmental horticulture support services (e.g., financial or legal), or other organizations not directly involved in production, sales, design, or provision of landscape services. Subsequently, such misidentified entities were removed from the list.

Once the questionnaire was drafted, a few members of the GGIA had the opportunity to review it. A few questions were rephrased to assure survey clarity. Questionnaires were distributed through two avenues: online and post mail. Initially, questionnaires were posted on the Internet allowing members to complete the survey online. The invitation to complete the survey was emailed to firms for which addresses were available on the list. However, email addresses were not available for all targeted firms. Therefore, after a period of four weeks, a printed copy of the questionnaire was mailed to potential respondents. As the cover letter attached to the mailed questionnaires indicated, participants could either complete the still accessible online version of the survey, or return the completed print copy of the questionnaire by mail. The first mailing identified 47 addresses defined by the postal service as undeliverable. Four weeks after the first mailing, the online survey was terminated and the second mailing of printed questionnaires occurred, which added another ten addresses to the "undeliverable" group. The final number of identified environmental horticulture firms was 920. This report is based on the data collected from 250 questionnaires returned by April 30, 2013, a response rate of 27.2%. Further data collection was discontinued because of the increased engagement in seasonal fieldwork. After deleting the incomplete records, 211 environmental horticulture firms were included in the current analysis.

3.2. Summary of descriptive statistics

The summary of survey data illustrates the extent of the plastic waste management issue. This data set, indicative of the environmental horticulture sector of Georgia, shows a considerable portion of firms discarded certain types of materials that could be recycled. Specifically, 46.6% of firms discarded recyclable plastic containers, while 28.7% and 19.3% of firms reported that they threw away recyclable flats and greenhouse poly, respectively.

Several basic characteristics of surveyed environmental horticultural firms are summarized as follows (Table 1). About 61% of firms located their headquarters in the Atlanta metropolitan area. The total revenue of a typical firm in 2011 was between $350,000 and $500,000, and the average number of employees was 22 people. Firms were engaged in multiple business activities, and their primary scopes included the design, construction, and installation of landscapes, and landscape maintenance, as well as wholesale container and in-ground nurseries. In addition, the survey instrument also posed questions asking a firm to describe its relationship with recycling providers, as well as whether additional recycling services were available in its county. A summary of responses shows that 43.5% of the horticulture firms maintained a relationship with companies providing recycling services, and 19.7% of firms were located in a county where recycling companies provide additional pick-up service for non-typical waste (i.e., large items, used equipment, batteries, chemicals, large volumes of plastic, etc.). Furthermore, firms were asked to address their self-reported constraints in performing recycling. Specifically, 34.1% of firms claimed the physical effort to ship as a limitation to recycle. Earlier reports suggested that collection costs (that correspond to shipping costs) amount to two thirds of recycling costs (EPA, 2003). A large proportion of firms (45.7%) reported that the storage on premises until collection was their major constraint. Storage of waste in general on the premises has been identified as a potential factor discouraging recycling and it appears to be a major barrier especially in the environmental horticulture area. Finally, 29.1% of firms thought that low return on the recycling investment hindered their recycling decisions.

In addition to the information about firm features, respondents who completed the questionnaire also shared several characteristics of themselves. For example, 80.7 % of the respondents were an owner or manager of the surveyed firms, and 82.5% of them had 13 or more years of formal education.

3.3. Model and estimation method

The main objective of this study is to investigate the environmental horticulture firm's inclination to recycle by examining their decision to recycle major plastic waste types. Regarding the recycling decision by plastic waste type, it is common to specify the observed decision as a binary choice variable assuming the value of one or zero (Greene, 2003). The current study involves the dependent variables indicating a firm discarding three types of plastics: plastic containers, flats, and greenhouse poly. Explanatory variables include two sets of variables: firm characteristics (such as revenue, number of employees, firm scope, and self-reported recycling constraints) and respondent characteristics (such as education level and position).

The probit regression is often used to estimate a binary decision model (Gujarati, 2003). However, in the current study, three dependent binary variables (i.e., disposal decisions of plastic containers, flats, and greenhouse poly) might be correlated with each other, because plastic items may be used together to produce or market the same group of plants (for example, plastic containers are placed on a tray to ease handling in a greenhouse coverd with poly). Therefore, the multivariate probit model is employed to consider the potential across-equation correlation (see Table 2).

4. Results

The chi-square test was applied to verify if the estimated model fits the data set well and is superior to the alternative estimation of three independent equations (one for each plastic waste type). Test results in Table 2 indicate that the model is robust in explaining and predicting the response variables well. In addition, results of the likelihood ratio (LR) test indicate that across- equation parameters (i.e., rho12, rho13, and rho23) are significantly different from zero (Table 2). The test outcome confirms that the multivariate probit model is superior to the three independently estimated probit equations leading to more efficient estimation results. In addition, the significantly positive correlation parameters indicate that environmental horticulture firms are more likely to discard their flats and greenhouse poly as well. Therefore, in practical terms, increasing the recycling of one type of plastic solid waste, such as plastic containers, would promote the recycling of other plastic solid waste types such as flats and greenhouse poly. This is very encouraging because efforts targeting just one type of plastic recycling will likely have broader impact.

Table 1
Descriptive statistics and variable definition.

Variable name	Variable description/units of measurement	Mean	Std dev
Dependent variables			
Disp. plastic	=1 if a firm throws away plastic containers that could be recycled	0.466	0.500
Disp. flats	=1 if a firm throws away flats that could be recycled	0.287	0.453
Disp. poly	=1 if a firm throws away greenhouse poly that could be recycled	0.193	0.395
Independent variables			
	Firm characteristics		
Revenue	Total revenue in 2011/in million $	0.779	0.567
No. of employees	Total number of employees in 2011	22	44.498
Scope design	=1 if landscape design, build, installation represents 50 percent or more of the firm business activity	0.704	0.458
Scope maintenance	=1 if landscape maintenance represents 50 percent or more of the firm business activity	0.848	0.360
Metro	=1 if a firm's headquarters in the Atlanta metropolitan statistical area	0.610	0.489
Relation with recycling companies	=1 if a firm has a current relationship with recycling companies	0.435	0.497
Additional services from recycling companies	=1 if the waste collection organization in the firm's county permits once or twice a year recycling of difficult to handle materials (such as large items, used equipment, batteries, chemicals, and large volume of plastics)	0.197	0.399
Shipment constraint	=1 if a firm believes that the physical effort to ship is a constraint limiting recycling	0.341	0.475
Storage constraint	=1 if a firm believes storage on firm premises until pickup is a constraint limiting recycling	0.457	0.499
Low return constraint	=1 if a firm believes return on investment is a constraint limiting recycling	0.291	0.455
	Respondent characteristics		
Education	=1 if respondent has 13 years or more of education	0.825	0.381
Manager/owner	=1 if respondent is the firm's owner or manager	0.807	0.395

Table 2
Multivariate probit estimation results of the decision to throw away plastic containers, flats, and greenhouse poly that could be recycled ($N = 223$).

Variable name	Plastic containers	Flats	Poly
Firm characteristics			
Revenue	0.099	−0.154	−0.464
	(0.274)	(0.290)	(0.316)
Log no. of employee	−0.002	0.068	0.430
	(0.122)	(0.131)	(0.151)[c]
Scope design	−0.407	−0.540	0.655
	(0.209)[a]	(0.210)[c]	(0.254)[c]
Scope maintenance	−0.119	−0.507	0.191
	(0.254)	(0.250)[b]	(0.296)
Metro	−0.420	−0.624	−0.569
	(0.191)[c]	(0.192)[c]	(0.212)[c]
Relation with recycling companies	−0.273	–	–
	(0.179)		
Additional services from recycling companies	−0.357	–	–
	(0.216)[a]		
Shipment constraint	0.351	–	–
	(0.189)[a]		
Storage constraint	0.515	–	–
	(0.175)[c]		
Low return constraint	−0.528	–	–
	(0.194)[c]		
Respondent characteristics			
Education	−0.613	−0.609	0.058
	(0.240)[b]	(0.235)[c]	(0.274)
Manager/owner	0.150	0.554	0.563
	(0.238)	(0.271)[b]	(0.304)[a]
Constant	0.863	0.570	-2.354
	(0.499)	(0.490)	(0.583)
Rho12			0.638
			(0.147)[c]
Rho13			0.286
			(0.137)[b]
Rho23			0.303
			(0.135)[b]
Log likelihood			−331.979
Wald chi-square (df = 26) (p-value)			75.61
			(<0.001)
Chi-square (df = 3) of LR test on H0: Rho's = 0 (p-value)			27.63
			(<0.001)

[a] $p < 0.1$.
[b] $p < 0.05$.
[c] $p < 0.01$.

Table 3
Marginal effects of statistically significant variables influencing the decision to discard recyclable plastic containers, flats, and greenhouse poly.

Variable name	Plastic containers	Flats	Poly
Firm characteristics			
Ln no. of employee	–	–	0.105
			(0.002)
Scope design[a]	−0.141	−0.162	0.160
	(0.002)	(0.003)	(0.004)
Scope maintenance[a]	–	−0.153	–
		(0.003)	
Metro[a]	−0.145	−0.188	−0.139
	(0.002)	(0.003)	(0.003)
Additional services from recycling companies[a]	−0.124	–	–
	(0.001)		
Shipment constraint[a]	0.327	–	–
	(0.026)		
Storage constraint[a]	0.178	–	–
	(0.002)		
Low return constraint[a]	−0.183	–	–
	(0.002)		
Respondent characteristics			
Education[a]	−0.212	−0.184	–
	(0.002)	(0.003)	
Manager/owner[a]	–	0.167	0.137
		(0.003)	(0.003)

Note: only significant marginal effects have been displayed (p-value < 0.1); bootstrap errors are in parentheses.
[a] Indicates the discrete change of dummy variable from 0 to 1.

Estimated coefficients and corresponding standard errors of explanatory variables in a multivariate probit model (Table 2) cannot be directly interpreted so marginal effects of statistically significant variables are calculated and shown in Table 3. Each marginal effect or effects (in the case of a binary variable) measures the change in probability of discarding certain type of solid plastic waste in response to a unit change in a statistically significant explanatory variable, and allows assessment of the relative impact of various determinants.

4.1. Decision to discard plastic containers

Whether a firm discards plastic containers is associated with the firm's business scope, its location, and whether it is located in an area offering additional pick-ups besides those already regularly scheduled. Specifically, an environmental horticulture firm with the business focus on landscape design, construction, and installation has a 14.1% lower probability of discarding plastic containers than firms with other business scope. It is quite plausible that firms with the former business scope use fewer plastic containers than, for example, ornamental plant producers such as nurseries.

A firm located in the Atlanta metropolitan area is less likely to make a decision to discard its plastic containers by 14.5% than its counterparts, located outside the area. Waste regulations and tipping fees tend to impose additional constraints in metro areas encouraging recycling, but also the waste collection services tend to be broader and more frequent than in rural areas. In a county where recycling companies provide additional pick-up service for cumbersome waste, the probability of the decision to discard plastic containers in landfills decreases by 12.4% as compared to counties where such extra service is unavailable. The recycling company's additional collection service makes a substantial difference and encourages environmental horticulture firms to recycle their plastic containers.

Furthermore, firms' self-reported recycling constraints are closely associated with their recycling decisions of three products. For instance, a firm concerned about the physical effort to ship recyclables is 32.7% more likely to favor the decision to discard the recyclable plastic material in landfills. Similarly, firms claiming that the storage on firm premises until a pick-up is their major recycling constraint have an 17.8% lower probability of deciding to recycle plastic containers. In contrast, a firm concerned about the return on investment is less likely to discard their plastic containers; the probability of the decision to discard decreases by 18.3% as compared to those who did not perceive return on investment as a constraint. Return on investment in an environmental horticulture company depends on costs, and if efforts to recycle generate costs, the incentive not to discard plastic containers is weak.

Respondent characteristics also matter when making a decision to discard any of the three types of solid plastic waste considered in their study. The more years of education a respondent received, the lower the probability of discarding plastic containers. The decrease in the probability of discarding containers is substantial – 21.2%. Less education may reflect less concern about long-term environmental quality protection or insufficient knowledge of potential health effects, both to humans and the natural environment from discarding solid plastic waste.

4.2. Decision to discard plastic flats

Results of the decision to choose to dump recyclable plastic flats are similar to those obtained in the case of plastic containers. The similarities are not surprising because flats are often used in the same production processes: shipment and installation in landscapes. A firm's disposal decision in relation to flats has been confirmed with regard to the business scope and location. A firm focused on the design, construction, and installation of landscapes is 16.2% less likely to discard recyclable flats. Firms concentrating on landscape maintenance services are 15.3% less likely to make the decision to discard flats. Such firms may have incorporated working routines that involve recycling because they cannot discard flats at the site where they provide maintenance services, for example the installation of seasonal ornamentals. The firm location in the metropolitan Atlanta area decreases the probability of the decision to discard flats by 18.8% as compared to firms located in non-metro areas. The sizable marginal effect of firm location suggests that a recycling program may need to target firms in non-metropolitan areas in order to advance overall recycling.

Owner or manager characteristics also influence the decision to discard plastic flats. If a respondent is the owner or manager of a firm, the decision to discard flats is 16.7% higher than if the person responding to the survey had a different position in the company. The result suggests that owners and managers are more concerned with other tasks than are other employees. In a competitive environment, the number of tasks and pressure to perform may supersede the manager's or owner's thoughts about how to dispose of waste, including plastic flats. However, the effect of education is negative and suggests that the probability to make a decision to discard flats decreases by 18% if a respondent received more than a high school education. This result is encouraging and stresses the relevance of educating all employees in the environmental horticulture sector about the opportunities and benefits of recycling.

4.3. Decision to discard greenhouse poly

In terms of greenhouse poly, a firm's decision to throw away this recyclable plastic waste is associated with the firm size, business scope, location, and respondent's position. A firm with a large number of employees is less likely to recycle their greenhouse poly. A large number of employees implies a rather large operation where the focus on productive tasks deemphasizes the handling of used greenhouse poly. Implicitly, a large operation generates a large volume of greenhouse poly, and recycling procedures may constrain production-related tasks, therefore making it easier to discard the poly. Firms focusing on the design, construction, and installation of landscapes have a 16% higher probability of discarding greenhouse poly than firms with other business scopes. Firms engaged in design and installation are not likely to use greenhouse poly in substantial volumes and the lower probability may be of less of a concern in their case. Firms located in the Atlanta metropolitan area are less likely to decide to throw away greenhouse poly than firms located in the non-metro areas; the probability of the decision decreases by 13.9%. Stricter regulations about waste disposal in general and, possibly, more options available to arrange waste pick-up may be responsible for the observed outcome. The result is consistent with those in the case of decisions to dispose of plastic containers and flats, reconfirming that firms from the Atlanta metropolitan area have a higher probability to recycle plastic waste in general.

Being a manager or owner of an environmental horticulture firm contributes 13.7% to the probability of deciding to discard greenhouse poly. The decision is possibly associated with the amount of time and effort it takes to separate and clean greenhouse poly so it can be collected by a waste management company. A manager or an owner may view poly recycling as a low priority, especially given its bulkiness and inconvenience resulting from handling and storing until an eventual pick-up by a recycler.

5. Discussion

Plastic waste generated by the environmental horticulture sector in Georgia presents a challenge for individual firms. Although reuse has been suggested as preferred to recycling (Al-Salem et al., 2009), the risk of pathogens in containers, flats, or trays requires labor-intensive cleaning and limits reuse to homeowners. Recycling of plastic waste from environmental horticulture firms is possible and this study examines factors that influence the decision to recycle vs. discard three types of plastic products. The specified relationships study firm and respondent characteristics and their influence on the decision to discard/recycle plastic waste by type applying the multivariate probit technique to account for simultaneous use of the three types of plastic products in ornamental plant production and provision of landscape services.

Business focus of the environmental company matters in its relationship to the decision to discard plastic waste. Companies with the predominant business focus on design and installation of landscapes tend to have a lower probability of discarding plastic waste than companies with another business focus within the scope of the environmental horticulture sector. The result is reasonable because plant producers routinely use plastic containers, flats, trays, and greenhouse poly, while plant installation in landscapes involves a limited number of such products.

The identified effect of business scope on the decision to discard plastic waste coincides with the effect of the company's location. Namely, firms located in the Atlanta metropolitan area are less likely to make the decision to discard plastic waste and their behavior likely reflects incentives provided to companies not to discard plastic waste. It is plausible that solid waste pickup is more frequent in the metro area. From a practical standpoint, the additional collection costs lowers the expected revenues from resold recyclable waste, while less solid plastic waste lowers the volume destined for landfills extending their life. However, major producers of ornamental plants are firms located in non-metro counties and to increase their participation in recycling may pose a challenge for county waste collection schemes. Yet another result indirectly provides evidence that alternative waste collection events like the collection of recyclable but difficult to handle waste lowers the probability of discarding plastic containers. It appears that such events are relevant in lowering the volume of plastics ending up in landfills and counties may reconsider increasing the frequency of such events. Additionally, timing of collecting difficult to handle waste can be crucial and should fall in periods when ornamental plant nurseries or greenhouses terminate production. Such termination may not strictly follow seasons, but can be easily determined through interaction with ornamental plant producers. More importantly, the increased opportunities offering plastic waste recycling also reduce other factors identified as constraints to recycle.

Constraints associated with the decision to discard recyclable plastic waste have been reflected in environmental horticulture companies' concerns about the costs associated with recycling. Shipping costs and storage of recyclables on premises encourage disposal of plastic containers to landfills. The perception that shipping constrains recycling increases the probability of discarding plastic containers by 32.7% and the opinion that storage on premises is a constraint increases the probability of the decision to discard plastic containers by 17.8%. Both constraints have been mentioned in earlier reports as a restriction in increasing recycling. The consistency with which these constraints are mentioned is

difficult to ignore and calls for implementation of more frequent collection of plastic waste from environmental horticulture firms. Additional pick-ups from firm premises make a measurable difference in lowering plastic waste volume sent to landfills.

Respondents with higher levels of educational attainment have a lower probability of disposing of plastic containers or flats. The effect was expected, but its statistical confirmation even more strongly supports the need for continuing efforts to educate the environmental horticulture sector about the consequences of disposing of plastics to landfills. Commonly, licensing environmental horticulture firm employees involves annual re-certification for obtaining pesticide application permits. Such training workshops offer an opportunity to build in a module about solid plastic waste disposal as an extension of instructions about pesticide container disposal.

In contrast to the effect of education, being a manger or owner of a firm increased the probability of discarding flats and greenhouse poly. The result is plausible given the primary goal of a firm is to generate revenues and lower costs. A manager or an owner addresses the tasks that directly affect the bottom line and for many, it implies that discarding solid plastic waste is easier than trying to recycle it. The identified behavior possibly reflects the difficulty of recycling some plastic products used in environmental horticulture and the additional effort on the part of the company to sort out plastics from all generated waste on premises. The effect has been confirmed in the case of flats and greenhouse poly, but not in the case of containers, which may be simpler to handle and therefore easier to recycle. Greenhouse poly may be particularly bulky, contaminated with dirt, and would require cutting into pieces to accommodate collection and, in addition, if a firm uses greenhouse poly, it uses it in large volume. The extra effort to prepare it for shipping can substantially cut into the firm's bottom line. Greenhouse poly recycling calls for a search for possible solutions.

6. Conclusions

Environmental horticulture firms in Georgia generate a significant amount of plastic waste in the form of plastic containers, flats, and greenhouse poly, which ends up in landfills. This study examines factors that affect the probability of the decision to discard (rather than recycle) plastic waste using survey data collected in 2013. Several firm and respondent characteristics have been confirmed to significantly influence the decision. Firm business scope lowers the probability of plastic container and flat disposal (by 16% and 18%, respectively) if a firm focus is design and installation of landscapes. Also, landscape maintenance firms are less likely to discard plastic flats (by 15.6%); plastic flats are commonly used for handling seasonal ornamental plants installed by maintenance firms in existing landscapes. The results imply a need for increased focus on ornamental plant producing firms in order to lower the probability of the decision to discard plastic waste in landfills. Because the environmental horticulture sector encompasses businesses with diverse scope, narrowing some efforts and targeting segments of the sector is needed to encourage increased recycling of plastic containers and flats. However, the probability of discarding greenhouse poly increases if a firm focuses on design and installation. The result likely reflects the very low volume of such material that, given its bulkiness, may be easier handled by a firm if discarded rather than recycled. Recycling greenhouse poly has been a problem with other horticultural and agricultural producers and the problem awaits a solution.

There is a difference in the probability of discarding any of the considered plastic type between firms located in the metro vs. non-metro areas. In all cases, being located in the Atlanta metropolitan area lowered the probability of discarding plastic waste suggesting that non-metro counties may need to increase their efforts to examine their current plastic waste recycling schemes to lower the volume of this waste type discarded in landfills. It is possible that tipping fee structures differ between metro and non-metro counties, providing cost-saving incentives if a firm lowers its volume of non-recycled waste, while also having potential penalties for discarding plastic waste. How much flexibility a county has in modifying the fee structure is likely specific to each county, especially given the presence and scope of the environmental horticulture sector.

More frequent plastic waste collection in all counties will lower the probability of discarding plastic containers. Increased opportunities for plastic waste recycling, for example by scheduling more frequent collection events focused on difficult materials, can lower the environmental firm's shipping costs and limit the storage on premises. Both have been identified as constraints that increase the probability of making the decision to discard rather than recycle.

Education makes a difference. Respondents with a higher educational attainment level were considerably less likely to discard plastic containers or flats. Education in the area of plastic waste recycling in the environmental horticulture sector may become a regular part of annual re-certification programs. For example, the extension service offers pesticide renewal license workshops every year and plastic waste recycling can be included when the disposal of pesticide containers is discussed. Such an approach would reach the majority of firms involved in production and landscape maintenance, likely the two types of businesses generating plastic waste such as containers, flats, and greenhouse poly.

Each environmental horticulture firm must generate profits to remain economically viable. In this context, the increased probability of discarding flats or greenhouse poly rather than recycling them is not surprising. For owners or managers, organizing the work that generates revenue is the main priority, and recycling is of lesser importance. To change the observed behavior, increasing the plastic waste collection frequency combined with education can alter the decision of discarding plastic flats or greenhouse poly; there was no confirmed effect in the case of plastic containers. Increased waste collection frequency lowers costs of shipping and shortens storage of used plastic products, while repeated educational programs can gradually change attitudes and permanently change behavior leading to increased recycling.

Plastic waste generated by the environmental horticulture sector has received little attention because the sector generates a relatively small volume of plastics. However, this study was motivated by the fact that in some areas the contribution of the plastic waste from environmental horticulture can be substantial. Firm and operator characteristics, including location, can either facilitate or limit the choice between discarding and recycling plastic waste and this study quantifies the changes in probability of such decisions, providing rare insights into the behavior of environmental horticulture firms. Knowledge of this behavior can be applied by local waste collection and recycling programs in Georgia and other areas with a sizable environmental horticulture sector. In a broader context, this study searches for a mechanism to encourage environmental horticulture firms to recycle more plastic waste with minimal regulation because regulation enforcement is costly to the community and firms. The path of regulation adopted by the EU member states with strong institutions still has implementation gaps suggesting that regulations in countries with weaker institutional arrangements may not fail. Knowledge of factors that influence decision to recycle specific types of plastic waste generated in environmental horticulture discerns the relative importance of each of them and allows to consider their relevance in other countries facing their own specific set of social, legal, economic and environmental conditions.

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