Determinants of Households' Adoption of Organic Pesticides: Evidence from Missouri

Lan Tran, University of Missouri-Columbia (LanTran@mail.Missouri.edu)

Laura McCann, University of Missouri-Columbia, (McCannL@Missouri.edu) and

Dong Won Shin, Korea Environment Institute (dwshin@kei.re.kr)

Selected Paper prepared for presentation at the 2019 Agricultural & Applied Economics Association Annual Meeting, Atlanta, GA, July 21-23

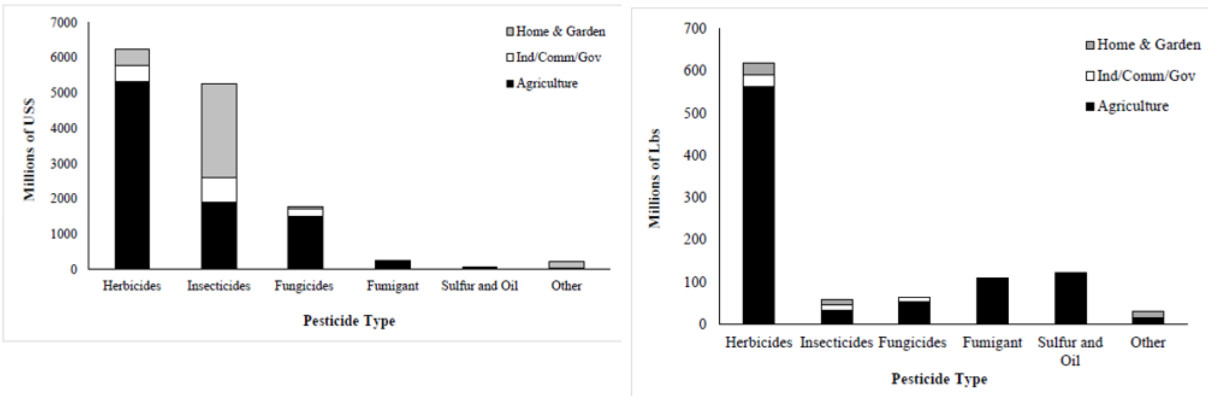
Abstract

This study investigates determinants of household's adoption of organic pesticides in lawn care management using evidence from a mail survey in Missouri. Residential lawns in Missouri often are damaged from weeds and insects and organic pesticides would be one solution for natural, organic or integrated pest management (IPM) lawn care. Using a set of demographic characteristics, environmental attitudes, perception of neighborhood attitudes, time spent on lawn care and other yard work habits, the study employs a multinomial logistic model given the unique dataset. We find that the relative risk ratio of being in the adopter category would be from 3 to 18 times more likely for more serious environmental concerns, and 0.096-0.463 times more likely for more time spent on lawn care with respect to non-adopters who had never heard of organic pesticides and non-adopters know them well, respectively. Critically, people who know organic pesticides well agreed with neighbor's aesthetic concern are more likely to be non-adopters by the relative probability of 1.54. Improved understandings about these factors for the organic pesticide adoption over complete choices of non-adoption are necessary for gardeners, policy makers, environmentalists and relevant companies.

1. Introduction

Lawns are popular in the United States; it is a source of enjoyment, a hobby and a source of value. Homeowners in the U.S. spent about $47.8 billion on lawn and garden retail sales in 2016, with a record average expenditure of $503 per household (Cohen, 2018). Pesticides are an important component; the home and garden sector accounted for about 6% of the total U.S. pesticide usage, valued at about 24% of conventional pesticide sales, compared to 66% by agriculture in 2012 (figure 1). The highest expenditure was for insecticides, approximately 80% of the total amount spent by households. Pesticides are used to prevent, destroy, repel, or mitigate weeds, insects and other pests, and thus maintain the aesthetic value of lawns and gardens, as well as providing an ideal setting for outdoor recreation, entertainment and relaxation. However, the negative impacts of conventional pesticides include water pollution, biodiversity loss and exposures in children (Robbins P. and Sharp J., 2003). Therefore, there has been increasing interest in less toxic or organic pesticides or free-pesticide practices for use in residential lawn care management (Marshall et al., 2015).

Figure 1. Pesticide expenditure and usage among sectors in the U.S. (2012)



Source: Atwood and Paisley-Jones (2017), *Pesticides Industry Sales and Usage.*

Regarding conventional pesticide reduction, potential alternative strategies for pest controls are integrated pest management (IPM) (pesticide applications based on monitoring and thresholds), organic (monitoring and need-based organic and natural product applications), and untreated lawn care techniques. In fact, there are overlaps among these three approaches since IPM and organic techniques try to seek organic or natural solutions rather than chemical ones whilst untreated lawn care programs are theoretically free of pesticides. Basically, organic pesticides can be found in IPM and organically managed practices for their less toxic and ready-to-use characteristics. A few studies show that organic pesticides may have similar or even greater negative impacts than synthetic ones do (Bahlai et al., 2010). With organic pesticide products, homeowners can either manage their lawn by themselves (following instructions labeled on the products) or request professional services for this purpose (Alumai et al., 2009).

While there has been increasing interest in organic lawn management in the U.S. with lots of adoption of organic management practices in public spaces (Marshall et al., 2015), the adoption rate of these practices for households is relatively low. For example, about 80% of households in Missouri used synthetic pesticides at least once a year, in which 57% of families use herbicides to control weeds and 50% of families use insecticides to control fleas and ticks on pets (Davis et al., 1992). What factors prevent organic pesticide adoption and use in lawn care management regardless of the safety offered by these products? Typically, profitability, risk, environmental and health concerns, and some demographic factors are important determinants of the adoption for best management practices (BMPs) by farmers (Prokopy et al., 2008). For lawn care management, the story may be a bit different. The aesthetic value of lawn would be the main concern in some households' preferences so that effectiveness of pest control practices is a priority (Marshall et al., 2015). In lawn care, the most common uses of pesticides are for weed control (herbicides) and killing insects (insecticides) but sometimes weeding is also a hobby or relaxing activity of gardeners, which imply gardener's habits are also an important factor for organic pesticide adoption. In addition, although commercial organic pesticides are more expensive than synthetic ones, this is not the case for home-made or natural organic pesticides which are often cheap (e.g. vinegar), leading to difficulties in comparing organic pesticide prices to chemical ones. Also, using no pesticides is also an option. In this study, conclusions and implications are drawn with a caution regarding price.

This paper explores determinants of household's adoption of organic pesticides in lawn care management using evidence from a mail survey in Missouri. A better understanding about factors affecting adoption from a homeowner perspective is necessary for gardeners, policy makers, environmentalists and companies. The existing literature on pesticides often focuses on methods, techniques rather than products, and when working with practices, most of the work on factors affecting adoption of pesticide control practices has been conducted with farmers rather than households. On the other hand, considering organic products the literature focuses on food consumption rather than use of items like cleaning products. This paper contributes to the literature on adoption of organic pesticide practices in lawn care management by synthesizing empirical studies of both organic consumption and organic farming/IPM. In addition, comparing and contrasting adopters and types of non-adopters for organic pesticide practices provides deep insights about characteristics of each group. Furthermore, this paper might be used as a reflection of pesticide use studies in lawn care management about role of pregnancy, children (Davis et al., 1992), neighbors' views (Blaine et al., 2012), and efficacy (Alumai et al., 2009).

In the next section, we present definitions of organic pesticides and factors affecting household's adoption of organic pesticides extracted from the previous literature. In the section that follows, we describe research methodology applied in this particular study, including conceptual framework, empirical model, and the unique dataset used in the study. Next, we report summary statistics of the data and the main empirical results of the model. Then, the paper ends up with a brief summary and a discussion of implications and limitations of the study.

2. Definitions and factors affecting household's adoption of organic pesticides

2.1. Definitions of organic pesticides

The concept of "organic pesticides" initially is found in organic agriculture – a farming practice that is defined as "… *an ecological production management system that promotes and enhances biodiversity, biological cycles, and soil biological activity … that restore, maintain, and enhance ecological harmony*" (USDA, 1995). By this definition, the term "organic" is associated with goals and approach of farming method rather than inputs used in the practice. On the other hand, as a kind of input distinguished from chemical pesticides, the term "organic" often is somewhat confusing as to whether it relates to elements of the pesticide or the way the pesticide is produced. In organic consumption, the USDA only strictly certified products with "Organic label" if the products are produced using allowed substances in the *National List of Allowed and Prohibited Substances* (The National List) along with suitable production methods and fulfillment of supervision of the National Organic Program regulated by the USDA. However, there may be non-certified organic products such as organic pesticides.

The National Pesticide Information Center (NPIC), a cooperative agreement between Oregon State University and the U.S. Environmental Protection Agency, provides an open list of commercial and homemade organic pesticides: bleach, pyrethrins, iron sulfate, copper sulfate, neem oil, vinegar, canola oil, salt, garlic, lemon grass, thyme, peppermint oil … in which the overlaps between organic pesticides, biopesticides and minimum risk pesticides are acknowledged. The Organic Gardener's Handbook of Natural Insect and Disease Control (Ellis and Bradley, 1996) refers to organically acceptable pesticides as organic control products used in gardens that have three characteristics: derived from natural substances, less toxic to humans than synthetic pesticides, and quickly breaking down in the environment to harmless substances. Given various definitions of organic pesticides, gardeners may identify them based on purpose (almost organic insecticides or organic herbicides), label (certified or uncertified by the USDA), production (home-made, natural-based or chemical-based), impacts (specific target pests, time issues, pesticide residue …) and information from dealers, retailers, extensionists, or neighbors. Hence organic pesticides generally often come with specific target pests, slow effectiveness, low residue levels with short persistence, and are thus likely to be safer than synthetic pesticides when their applications follow the label instructions carefully.

2.2. **Factors affecting household's adoption of organic pesticides**

The literature on residential adoption of organic pesticides used in lawn care is complex. Households buy organic pesticides to use as inputs in a home production activity like lawn care and then enjoy their lawn on a daily basis. The adoption of inputs like organic pesticides in home production can be seen from organic agriculture or IMP practices while the adoption of products like organic pesticides in terms of end users of lawns or gardens may be considered from organic consumption perspectives. Hence, the literature herein covers studies of both organic consumption and organic or IPM practices in agriculture. Most studies of household organic purchases examine consumers of food (e.g. Li et al., 2007; Asif et al., 2018; Janssen, 2018), or specific kinds of food like fresh vegetables or fruits (e.g. Boccaletti and Nardella, 2001; Saba & Messina, 2003; and Bond et al., 2008), and drinks (Schäufele & Hamm, 2018), but only few cases examine products for other purposes (Van Doorn and Verhoef, 2015). On the other hand, studying determinants of adoption of pesticide best management practices, work has primarily focused on farmer or agricultural producers rather than households (Prokopy et al., 2008; Baumgart-Getz et al., 2012, Rofle and Gregg, 2015). For a complete literature review of organic pesticide adoption in lawn care from a household's perspective, this paper also examines other studies that explore demand or preferences of households for organic cleaning products (Bach & Rosner, 2008; Steingraber, 2011; Laferriere et al., 2014) or organic lawn care practices in general (Tukey, 2007; Morris & Bagby, 2008; Pennington, 2010; Larson, 2017; Burr et al., 2018; McCann & Shin, 2018). The following section will list potential determinants found from these literatures.

Demographic variables (gender, age, education, income, household size):

In empirical models, some socio-demographic characteristics work as control variables which show important differences between group of adopters. In the literature of organic purchases, for example, women might be more likely to buy organic products, because they express more concern for communal goals than men (Winterich et al., 2009) or they become more proactive to prevent their new or coming baby from harmful effects of chemical products (Laferriere et al., 2014). In the context of organic production, women are also likely to be organic producers for the same reasons (Veldstra et al., 2014).

Household's income level consistently shows a positive effect on adoption of both organic purchase (Janssen, 2018; Van Doorn and Verhoef, 2015; Shashi et al., 2015) and best management practices such as organic agriculture and IPM (Prokoby et al., 2008; Blaine et al., 2012) because this helps adopters overcome cost issues of organic products or innovations. We will leave cost issues of organic pesticides to a discussion of price consciousness at the end of this literature review.

There are not such clear effects for household size, homeowner's age and education in empirical studies of organic adoption. Large households might have a negative effect on organic purchase behavior because this makes income per capita decrease (Van Doorn and Verhoef, 2015), but it does not matter for adoption of organic production. The number of children, which is highly correlated with household size, affects organic consumption in the same way, however regarding health and safety issues the impact of children seems to be sensitive with this result, which suggests careful analysis using a health or safety consciousness approach. Young people might have higher probability to buy organic food than older people (Dettmann & Dimitri, 2009; Yadav & Pathak, 2015) and they might more easily adopt organic farming methods rather than older people who are often considered as experienced farmers (Veldstra et al., 2014), but the relationship between age and probability of BMPs adoption is also insignificant in a few studies (Brehm et al., 2013). Similarly, higher educational level of homeowners tends to result in pesticide-free purchases (Ngobo, 2011; Shashi et al., 2015; Janssen, 2018) or use of organic practices (Genius et al., 2006), but the relationship is insignificant in other studies (Veldstra et al., 2014).

Environmental knowledge and attitudes

Although education sometimes shows insignificant effects on organic adoption, environmental knowledge and attitudes always are identified as critical drivers of adoption of pesticide use in the literature. Most empirical studies about organic consumption show positive effects of knowledge about organic products, awareness of threats from using synthetic pesticides, concerns about current quality of soil and water, or general attitudes of environmental protection on purchase intention (Magnusson et al., 2003; Dreezens et al., 2005; Lea and Worsley, 2005; Hughner et al., 2007; Jassen, 2018). However, the approach based on intended purchase is problematic because of the gap between behavior and attitudes toward organic products (Vermeir and Verbeke, 2006) or potential biases when it comes to environmentally-friendly purchasing behavior (Moser, 2016). Additionally, a few studies show that environmental knowledge and attitudes actually do not positively reflect actual purchase of organic products (Jassen, 2018), and consumers might overestimate their organic purchases (Hughner et al., 2007).

In the literature on organic farming, environmental knowledge and attitudes also play an important role in the adoption of organic and IPM practices (Prokopy et al., 2008; Reimer et al., 2012; Riar et al., 2017). However, the impacts of environmental knowledge and attitudes on farmer's pesticide adoption are different from consumer's purchase of pesticide-free or less pesticide products in term of sensitivity. Consumers are likely to alter their behavior more easily than farmers do under awareness of serious environmental degradation, strict subjective norms, and high expectation of environment quality (Beedel & Rehman, 2000; Reimer et al., 2012). On the other hand, the effect of knowledge on farmers' environmental behavior may differ across several situations: little comparing to personal beliefs and emotions (Grob, 1995), insignificant because of lack of trust of information sources (Jin et al., 2014), or unpredictable because of calculativeness of farmers under uncertainty and complexity of pesticide resistance (Philbert et al., 2014). Extending the concept of organic agriculture to lawn care management, households with more knowledge of lawn care are more likely to adopt BMPs (Brehm et al., 2013).

Personal health and safety consciousness

In the literature on adoption studies, personally/individually perceived benefits and costs associated with the implied innovation undoubtedly are the main factors affecting the adoption decision. While environmental knowledge and attitudes express public or general benefits, personal health and safety is critical to represent individual benefits. Many studies show that organic agriculture and IPM techniques help farmers reduce or avoid threats of chronic poisoning almost causing cancer due to direct or indirect exposure to chemicals while farming (Singh et al., 2007). Regarding organic consumption, organic products often are perceived as healthier or safer than conventional ones (Magnusson et al., 2001; Lea & Worsley, 2005), that leads to higher adoption rate of organic products to avoid health risks (Makatouni, 2002; Padel & Foster, 2005). That's why women and children who are the most exposed to conventional or chemical products often show preferences for organic products as we found above in the demographic section.

In the context of lawn care management, health issues become more serious since household members daily enjoy the lawn treated with pesticides (USGS, 1999; Robbins & Sharps, 2003) which leads to adoption of organic lawn care. Children are highly exposed to chemicals when they often play on yards and pesticides or pesticide residue may touch their skin. Hence, households who have children tend to adopt organic and natural pesticides rather than conventional ones (Davis et al., 1992; Alumai et al., 2009). However, the number of children may negatively affect the organic pesticide adoption as we discussed above for possible interaction effect with average income, which implies more research is needed on this relationship (Janssen (2018); Boizot-Szantai et al. (2017)).

Expectations of property value (yard appearance, quality and enjoyment)

In addition to the safety reasons, expected quality of products obtained by using an innovation can affect its adoption. Past studies in both the literature of organic purchase and organic production often view organic products as having good flavor (Radman, 2005), high vitamins (food) (Lea and Worsley, 2005) or generally better in term of pesticide residues (Gomiero, 2018) which lead to consumers buying them with higher probability than conventional products (Huang, 1996; Lockie et al., 2002; Baker et al., 2004). Regarding lawns, the concept of quality may include property value, aesthetic value (lawn appearance) and other biological values. In general, households who expect organic lawn management may improve their property values are more likely to adopt this practice rather than others (Blaine et al. 2012). On the other hand, if the household only considers the appearance of lawn – or if they care about neighbor's attitudes about their lawn, they might be more likely to adopt chemical pesticides, especially preferring to use commercial management to Do-it-yourself (DIY) practices (Alumai et al., 2009).

Individual preference that relates to enjoyment of lawn work may affect the adoption of organic lawn management. For example, people who are more interested in gardening and able to do lawn work tend to adopt alternative lawn care practices (McCann and Shin, 2018) because they may gain more utility from best management practices.

Perception of neighbors' attitudes and practices

Perception of neighbors' attitudes and practices often is considered in the literature on adoption. From neighbors' viewpoint, increased chemical pesticide use causes loss of biodiversity, landscape simplification and other harmful impacts (Meehan et al., 2011) then as a result, homeowners who might be affected by neighbors are likely to adopt pesticide restriction techniques to reduce negative impacts in the neighborhood (Nassauer et al. 2009; Reimer and Prokopy, 2012). Extending this result to the other side, whether households might employ a lawn care company applying chemicals and pesticides depends on whether neighbors and other people in the neighborhood use them (Blaine et al, 2012). As shown in the preceding discussion, yard appearance is often an important reason why homeowners take care of their lawn, and then people in a neighborhood tend to share the same view of aesthetic value of home lawn and garden, leading to favoring chemical pesticides which are normally perceived to work perfectly in terms of pest control. Hence, the effect of perception of neighbors' attitudes and practices on organic pesticide adoption needs to be defined cautiously. The effect is negative for yard or landscape appearance, and it is positive for environmentally-friendly landscaping.

Price consciousness (financial cost)

While safety and high quality or enjoyment of an organic lawn deliver benefits to households, the price of organic products or cost of using organic methods present barriers to their adoption. In the literature, consumers often perceive organic products as expensive comparing to conventional ones which implies the price negatively affects organic purchases (Magnusson et al., 2001; Lea & Worsley, 2005). However, in the context of agriculture, the total cost can be lower if farmers can save by adopting organic techniques along with organic or chemical-free pesticides, even though they often pay more for labor as a substitute input. Availability of labor at a cheap wage (relatively lower than pesticide cost) might positively affect adoption of organic agriculture (Gudade et al., 2014). Similarly, the price of commercial lawn management is the most expensive, followed by DIY with synthetic pesticides, and organic lawn management respectively, which implies organic lawn management has some advantages of cost in the adoption, especially taking many homemade organic pesticides into account for financial costs (Alamui et al., 2009). However, the advantage of cost or price need to be considered along with the associated quality. Previously, the quality in term of aesthetic value obtained by organic lawn management is generally lower than one offered by commercial lawn management hence the effect of financial cost may depend on what adopters like most.

Convenience (cost of time)

Beside financial cost issues, convenience was considered as a barrier to organic adoption in the past. The concept of convenience refers to the amount of time used for new practices including installment time. Past studies found that consumers did not switch to organic products due to convenience reasons like availability of organic products (Magnusson et al., 2001) or search time (Jolly, 1991). However, the implementation of USDA's national organic standards in 2002 has addressed these issues by providing assurance of consistent, standardized production and processing of organically labeled foods (Greene and Kremen, 2003). Additionally, the "Walmart" effect on organic product market since 2006 basically dealt with the convenience issues (Li et al., 2007; Constance & Choi, 2010). Regarding production, convenience may be considered as availability or flexibility of inputs to produce organic products, for example availability of labor (Gudade et al., 2014). Lawn care management with pesticide use can be analyzed in the household production-consumption model of Becker (1965) (Templeton et al., 1999). In this model, the indirect utility of household decreases with chemical pesticide use, but increases with leisure hours, and has mixed relationship with lawn work depending on each household. Hence, time scarcity may negatively affect the adoption of organic lawn management.

Organic pesticides are considered to be potential replacements of conventional pesticides in residential lawn care management because of their safer and ready-to-use characteristics. However, the household's adoption rate of organic pesticides is currently low. By merging the literature of organic consumption, organic farming as well as IPM practices, and lawn care management practices, this paper extracts potential determinants of the organic pesticide adoption in lawn care from a household's perspective as in table 1.

Table 1. Hypothesized effect of factors affecting organic pesticide adoption

	Organic consumption	**Organic agriculture/ IPM**
Demographic variables		
- Young	(+)	(+)
- Women	+	+
- High education	(+)	(+)
- High income	+	+
- Large household	-	-
Environmental Knowledge and Attitudes	+	(+)
Personal health and safety consciousness	+	+
- Having children	(+)	
Expectations of property value		
- Yard appearance		-
- Enjoyment		+
Perceptions of neighborhood attitudes	+/-	+/-
Price consciousness	-	-
Convenience	(-)	(-)
- Time scarcity	-	-

Note: (+) or (-) means the signs are insignificant in some studies; +/- means the sign depends on the sign of another factor, for example neighbor's environmental concern (+) or neighbor's expectations of aesthetic value (-)

In general, several demographic variables like gender and income level show positive effects on organic pesticide adoption while the effects of age and education may be not significant. Environmental knowledge and attitudes, personal safety, enjoyment of lawn work may be important factors positively affecting the use of organic pesticides while yard appearance and time scarcity have potentially negative impacts on adoption. Enjoyment and time spent on lawn work are attributes of gardeners, which implies homeowner's habits and specific characteristics of lawn such as intensive herbicides, intensive insecticides or both, and pesticide resistance possibly affect adoption. On the other hand, environmental and health concerns, expectation of property value, and perception of neighborhood's landscape depend on the homeowner's mindset and knowledge. There are various combinations or interactions of those attributes or dimensions, leading to difficulties in the classification of adopters for organic pesticides. There exist gaps in the literature regarding the role of children, perception of neighborhood attitudes, convenience, knowledge under uncertainty and complexity of pesticide resistance on organic pesticide adoption from residential lawn management perspectives.

3. Research methodology

3.1. Conceptual framework

The study considers households' organic pesticide adoption as an individual choice. Rogers's diffusion of innovation theory is the most influential theory that seeks to explain how, why, and at what rate new ideas and technology spread (Roger, 2010). Rogers provides a foundational understanding about adoption (Straub, 2009). In this study, adoption behavior is expressed by individual choice of accepting or rejecting a particular innovation: organic pesticide practices used in residential lawn care. Random utility models underpin discrete choice framework such as adoption behavior (e.g. Luce, 1959; Mc Fadden 1974; Ben-Akiva and Lerman, 1985).

Considering the choice to use organic pesticides or not, the utility to the household of alternatives is specified as a linear function of characteristics of the household and the attributes of the alternative plus an error term. Hence, we have a set of random utilities for an individual, in which each utility is associated with each alternative, and each with its own error term. The probability that a particular household will choose a particular alternative is given by the probability that the utility of that alternative to that household is greater than the utility to that household of all other alternatives. In this way, the household picks the alternative that maximizes his or her utility. Because utility is defined with both non-error components and error terms, the values of errors are also important to determine the optimal alternative. The fact that error terms are defined as random or stochastic, unobserved or latent factors, assumptions on error terms play a key role. If the random utility error terms are assumed to be independently and identically distributed as a *log Weibull distribution*, the multinomial logit model results, on the other hand if the error terms are supposed to follow a *multivariate normal distribution*, the multinomial probit model results (Kennedy, 2003). In general, the multinomial logit (MNL) model is widely preferred to model choices among mutually exclusive alternatives. The main advantages of MNL models come from its simplicity in terms of both estimation and interpretation of the resulting choice probabilities and elasticities as well as likelihood function can be formed and maximized in a straightforward way with maximum likelihood estimators (MLE), without assumptions of normality, linearity or homoskedasticity. The only important assumption is independence among the dependent variable choices (IIA) that can be tested by the Hausman-McFadden test.

Households' adoption decisions are based on a range of factors. Based on the literature of organic purchases and adoption of organic agricultural practices that incorporate the household production-consumption model of Becker (1965), we identify three categories of factors: (1) socio-demographic variables (age, gender, education, income, having children under 12); (2) environmental knowledge and attitudes (concerns of excessive pesticide use, concerns about neighbor's opinions); (3) lawn management behaviors (monthly hours spent for lawn care or yard work, average number of weeds per square yard, using professional service for pest control). Other factors are included in unobservable group.

3.2. Empirical model

Assuming revealed preferences for conservation practices, household choices of currently using or not using organic pesticides in lawn care management can be considered as adoption or non-adoption decisions respectively (Lichtenberg, 2004). Applying a random utility framework for these alternative choices, the study employs a multinomial logit model to predict the likelihood of household choices given a set of explanatory factors (x):

$$P(y_i = j) = \frac{exp\left(x_i \beta_j\right)}{\sum_{k=1}^{5} exp\,(x_i \beta_k)}$$

Specification:

- $i = 1$ to n, where n is sample size of the study
- $j = 1$ to 5, where options are (1) Currently use organic pesticides; (2) Never heard of it (3) Know somewhat, but not using it; (4) Know well, but not using it; (5) Not applicable. Option (1) represents adopters while options (2) – (5) are distinct types of non-adopters.

- X: vector of factors affecting household decisions: Age (X1), Gender (X2), Education (X3), Income (X4), Having children under 12 (X5), Environmental concerns of excessive pesticide use (X6), Importance of neighbor's opinions regarding nice lawn (X7), Monthly hours spent for lawn care (X8), Weed density (X9), and Hiring professional pest control companies (X10).
- ε: unobservable factor which is treated as error ~ N(μ, σ)

The MNL model is estimated using MLE method as discussed above. There are various computational packages in R to deal with this estimation without regularization such as *mlogit*, *nnet*, *VGAM* and so forth (Hasan et al., 2016). Basically, the results from these packages would be little different.

3.3. Data

The dataset comes from the 2014 Hinkson Creek Household Survey in Columbia, Missouri. This is a mail survey with a questionaire including questions about lawn care management practices used for water quality and yard work at the household level in the Hinkson Creek area, and information on household's characteristics, homeowner's environmental attitudes and how people get information for their yard, water quality and practices. Hinkson Creek is located at Boone county in Columbia, Missouri. Land use and land cover of this area are dominated by grass and forest. There are about 10,000 housing units in Columbia, in which 80% of households are homeowners (U.S. Census Bureau, 2010). A random sample of 2000 residents was obtained from Survey Sampling International, using ZIP codes (65201, 65202, and 65203). The survey focused on detached single-family homes. The person in the household most responsible for lawn care was asked to complete the survey. Of 1773 questionaires mailed to valid addresses, there are 783 completed ones resulting in an effective response rate of 44.1%.

All variables are constructed from the survey results. The dependent variable, adoption of organic pesticides, is implied by completed choices in the questionaire: (a) Not applicable, (b) Never heard of it and not using it, (c) Somewhat familiar with it but not using it, (d) Know how to use it but not using it, and (e) Currently use it. In this study, "e" implies "adoption", and "b", "c", "d" represents three possible type of non-adoption which differ across information or knowledge. The choice "Not applicable" also means residential non-adoption of organic pesticides for some latent reasons possibly including currently using untreated lawn care practices, no availability of necessary organic pesticides to apply, using professional pest control companies without organic pesticide options and so on, and this may be different the from “no information” option. To avoid loss of information for “not applicable”, this choice is still considered as a level of the dependent variable for non-adopters, but it is treated separately with caution (see later in *Discussion*). Frequencies of “e”, “b”, “c”, “d” and “a” are 134, 42, 218, 180, and 184 respectively for the sample of 758 observations, after removing missing data of the dependent variable. Thus, the adoption rate for organic pesticides is 17.7% in this sample.

The study uses 10 independent variables to predict adoption behavior of homeowners for organic pesticides. Of these predictors, socio-demographic variables include “gender”, “age”, “education”, “income”, “having children under 12”. The main explanatory variables here are environmental attitudes represented by “environmental concern of extensive pesticide use”; importance of aesthetic value described by “perception of neighbor’s opinions of have a nice lawn”; and household’s lawn care behaviors which are measured in term of “monthly hours spent for lawn care”, “average number of weeds per square yard”, and “hiring pest control service or professional company”.

Summary statistics of all variables from the dataset can be found in table 2. These statistics are reported separately for adopters and types of non-adopters. For categorical variables, we only report the proportions by column of each level to the corresponding total of levels. For example, for adopters 57.1% of households are male while the rest 42.9% are female. Although the variables like Age, Education, and Income are intrinsically ordered categorical ones, they are measured in a nominal way in this study. This is an appropriate coding scheme since there are no monotonic effects of these variables on the dependent variable in the literature. In this way, people with age > 60, or education level at bachelor or some college, or household income level at $100,000 and above seem to be adopters with the mean of 42.9%, 56.4%, 31.2% respectively. Similarly, the variable “Environmental concerns regarding excessive use of pesticides” is coded in nominal way because the choice “Don’t know” cannot match the order and this choice might also differ from usual missing information option.

Importance of neighbors’ opinion regarding nice lawn is the only predictor using scale measurement which is evaluated by Likert scale from 1-5. For continuous variables, we report mean values and corresponding standard deviations (SD). The mean of adopters is 2.917 and the SD is 1.034, implying most adopters indicate 2-4 for neighbors’ opinions regarding nice lawn.

The lawn care behaviors include time spent for lawn care and yard work as well as weed density may be measured in an ordinal way. More monthly hours spent on lawn care seems to be associated with being an adopter; the mean is 40.2% of group spending more 15 hours per month. However, the largest proportion of adopters (60.2%) indicate they have a low density of weeds (1-10 weeds per yard square) while adopters are the least likely to say they have zero weeds.

Table 2. Summary statistics for categorical variables

Variables	**Adopters**	**Non-Adopters**			
		Never heard	**Know somewhat**	**Know well**	**Not Applicable**
Dependent Variable	17.7%	5.5%	28.8%	23.7%	24.3%
Predictors					
Male	57.1%	66.7%	68.1%	67.4%	57.1%
Age					
18-30 years	4.5%	9.5%	9.7%	6.2%	12.1%
31-45 years	23.3%	28.6%	25.8%	27.5%	23.1%
46-60 years	29.3%	33.3%	33.6%	27.0 %	31.3%
> 60 years	42.9%	28.6%	30.9%	39.3%	33.5%
Education					
High school and lower	7.5%	9.8%	10.1%	10.6%	13.7%
Bachelor or some college	56.4%	56.1%	54.8%	56.71%	48.9%
Post graduate	36.1%	34.1%	35.1%	7.6%	37.4%
Income					
$0- $24,999	4.0%	17.6%	5.5%	4.0%	10.9%
$25,000-$49,999	21.6%	23.5%	15.6%	21.6%	27.3%
$50,000-$74,999	28.8%	14.7%	26.6%	25.3%	27.9%
$75,000-$99,999	14.4%	23.5%	19.6%	17.6%	14.5%
$100,000+	31.2%	20.6%	32.7%	32.9%	19.4%
Have children under 12	19.4%	29.3%	25.1%	27.5%	22.1%
Environmental concerns regarding excessive use of pesticides					
Not or slight problem	9.8%	26.2%	23.4%	18.0%	22.8%
Moderate problem	37.6%	35.7%	38.5%	39.9%	30.4%
Severe problem	40.6%	11.9%	27.5%	30.9%	25.5%
Don't know	12.0%	26.2%	10.6%	11.2%	21.2%
Importance of neighbors' opinion regarding nice lawn (*)	2.917 (*1.034*)	3.143 (*.977*)	3.106 (*.946*)	3.117 (*1.021*)	2.940 (*1.041*)
Monthly hours spent for lawn care					
0-5 hours	9.8%	26.2%	18.1%	14.0%	32.2%
6-10 hours	25.0%	47.6%	38.6%	34.3%	34.4%
11-15 hours	25.0%	14.3%	22.3%	27.0%	16.7%
> 15 hours	40.2%	11.9%	20.9%	24.7%	16.7%
Number of weeds per square yard					
None	3.2%	31.8%	9.7%	11.6%	10.2%
1-10 weeds	60.2%	40.9%	47.6%	51.9%	53.7%
11-40 weeds	26.9%	22.8%	32.4%	32.6%	29.6%
> 40 weeds	9.7%	4.5%	10.3%	3.9%	6.5%
Hire Pest Control service	22.0%	21.4%	20.6%	17.9%	16.5%
Number of observations	**134**	**42**	**218**	**180**	**184**

Note: (*) we report mean value of continuous variable and the corresponding standard deviation in bracket for all adopters and non-adopters.

The variables “gender”, “having children under 12” and “hiring pest control service from professional company” are treated as dichotomous. 57% of adopters are male which is slightly lower than the other adopter categories. A smaller proportion of adopters have children under 12 which is unexpected from our previous predictions. Adopters seem to be more likely to hire pest control companies, which may indicate that they are concerned with appearances, but this is contrary to expectations.

From table 2, we also see signals that non-adopters are different from adopters in some demographic variables, environmental concerns regarding “severe problem” or “not/ slight problem” of excessive pesticide use, importance of neighbors’ opinion regarding nice lawn, time spent for lawn care, and weed density. The probability of males being non-adopters of “never heard of it”, “know somewhat but not using it” and “know well but not using it” are higher than one of male adopters, about 66-68% versus 57.1%. Moreover, older people seem to be adopters (42.9%) rather than non-adopters or “not applicable” (33.5%), “never heard of it” (28.6%), “know somewhat but not using it” (30.9%) while they are similar when considering non-adopters who “know well” (39.3%). While there are no big differences in education and income among adopters and non-adopters, households who have children under 12 are a bit different between adopters and non-adopters of “never heard”, 19.4% versus 29.3% although the gap is smaller for other non-adopters: “not applicable”: 22.1%, “know somewhat”: 25.1% and “know well”: 27.5%.

Environmental concerns as “severe problem” for excessive use of pesticides of adopters is considerably higher than ones of non-adopters (40.6% versus 25.5%, 11.9%, 27.5%, 30.9%); while adopters’ choice “not/ slight problem” is much lower than non-adopters’ one (9.8% versus 22.8%, 26.2%, 23.4%, 18.0%). Further, there are big gaps between the choices of “never heard” and “know well”: 11.9% vs. 30.9% for “severe problem” and 26.2% vs. 18% for “not/ slight problem”. For “importance of neighbor’s opinion regarding nice lawn”, the mean of adopters is smaller than ones of all types of non-adopters. The difference is the biggest when comparing to non-adopters of “never heard”: 2.917 vs. 3.143, and it is smallest when comparing to non-adopters of “not applicable”: 2.917 vs. 2.940.

While most adopters spent more than 15 hours a month, non-adopters seemed to spend 6-10 monthly hours on lawn care. The differences are the biggest when non-adopters are of “never heard”, particularly for “6-10 hours”: 25% vs. 47.6%, and for “greater than 15 hours”: 40.2% vs. 11.9%. Moreover, the gaps are also big between non-adopters of “never heard” and ones of “know well" at every interval of hours. For low weed density (average 1-10 weeds per square yard), there are big differences between adopters and non-adopters for: 60.2% versus 53.7%, 40.9%, 47.6% and 51.9%. In addition, non-adopters "never heard" are quite different from other non-adopters.

The above summary statistics provide some signals to predict the likelihood or probability of non-adoption relative to adoption. To identify significant factors affecting the adoption of organic pesticides relative to other non-adoption decisions, regression analyses are used in the next section. Before the regression analysis, a correlation test of all predictors shows that none of correlation coefficients for pairs of those variables are significantly higher than 0.5, implying no multicollinearity appears for the regression.

4. Estimation results and discussions

We start by discussing the estimation results and their interpretation. The estimation results are presented in table 3. An important feature of MNL models is that they estimate (k-1) models where k represents the number of levels of outcome variable. In this paper, the reference or base category of the outcome variable represents the adoption decision while the others are distinct types of non-adopters. Hence, we have 4 model results corresponding to four types of non-adopters as compared to adopters.

Since the parameter estimates are relative to the reference group, interpretations always imply the relative probability of non-adoption with respect to adoption given the set of explanatory variables. For example, for a unit change in "importance of neighbors' opinions regarding nice lawn", the logit or the multinomial log-odds for preferring non-adoption "j" to the adoption would be expected to change its parameter estimate (β_7), all else equal. One may concern the relative probability or relative risk ratio so that exp(β_7) is computed to indicate that given one unit increase in X7, the relative risk of being in the non-adoption group "j" would be exp(β_7) times more likely or ratio of the probability of non-adoption "j" occurs to the probability of adoption occurs would be exp(β_7) more likely, all else equal. For a categorical predictor, we need to modify the interpretation since a one unit change in this variable does not make sense. Each categorical predictor also has reference level so that parameter of each specific level of this variable is estimated and the logit for preferring non-adoption "j" to adoption would be expected to change its parameter estimate relative to the reference level. However, for ordered categorical variables, reference level would be the lowest or the highest one to make the one unit change be equivalent to a change from the reference level to the next one in the predetermined order. Generally, a positive parameter estimate means the relative risk ratio is greater than 1, implying the choice would be classified to non-adoption “j” rather than the adoption and vice versa. In other words, a positive parameter estimate is more likely to be favor of types of non-adoption while a negative one implies the factor is associated with adoption of organic pesticides.

Table 3. Multinomial logit regression results with adopt as the base

Independent Variables (Factors)	**Non-Adopters**			
	Never heard	**Know somewhat**	**Know well**	**Not applicable**
Male	-.202	.211	.041	.001
Age (base: > 60 years)				
18-30 years	.872	1.130*	.213	1.132*
31-45 years	-.904	.033	-.205	.135
46-60 years	1.141	.304	-.286	.311
Education (base: bachelor or some college)				
High school or lower	.376	-.001	-.057	.188
Post graduate	.463	-.001	.043	.520
Income (base: $100,000 and above)				
< $24,999	1.094	-.672	-.493	.447
$25,000-$49,999	1.478	-.078	.127	.830
$50,000-$74,999	.262	-.069	.382	.551
$75,000-$99,999	.986	.105	-.103	.601
Having children under 12 (base: No children)				
More than 1 child	.631	.077	.560	-.325
Environmental concern regarding pesticides (base: Severe problem)				
Not or slight problem	2.872***	1.456***	1.107**	1.728**
Moderate problem	1.081	.154	.016	-.147
Don’t know	1.929*	.432	.248	.825
Importance of neighbors’ opinions regarding nice lawn	.391	0.376**	.429***	.352**
Monthly hours spent for lawn (Linear effect)	-2.345***	-.979***	-.771**	-1.524***
Number of weeds per square yard (cubic effect)	-4.278	-.411	-.612**	-.404
Pest Control service from company (base: No)				
Use service	-.089	-.308	-.245	.016
Constant	-8.881	-.907	-.975	-2.024**
Goodness of fit				
N	449			
LR ChiSquare (88)	129.45			
Pr(>Chisquare)	.002681			
AIC	1392.958			
Pseudo R^2 (Mc Fadden):	9.7%			
Pseudo R^2 (Cox & Snell	25.0%			
Pseudo R^2 (Nagelkerke)	26.4%			

*Notes: Superscripts *, ** and *** indicate statistical significance at the 10 percent, 5 percent and 1 percent levels, respectively.*

Table 3 shows that the full model fits the data well at alpha-level of 1% with the likelihood ratio test for goodness of fit. Three pseudo R squares are 26.4%, 25.0%, and 9.7% for Nagelkerke, Cox & Snell, Mc Fadden pseudo R^2 respectively. Generally, these values are acceptable from the literature when comparing to other studies (McCann and Shin, 2018). However, this opens room for adding more variables to obtain better model fit. Considering the current set of variables, several results are found as follows.

The study confirms gender, education and income as statistically insignificant factors affecting organic pesticide adoption using in lawn care management. Only one age coefficient estimate is significant: people who are from 18 to 30 years old rather than greater than 60 years (the reference category) are more likely to be non-adopters "know somewhat" or "not applicable" rather than to be adopters of organic pesticides. In other words, comparing old people (> 60) to young people (18-30), old people are more likely to adopt organic pesticides. The main differences between youngest and oldest people in the sample may be the oldest people are retired and able to spend more time per month on lawn care than youngest ones do. For example, in group of people who spent more than 15 hours a month, the oldest people represent 40.4% versus 3.8% of the youngest ones.

The study fails to detect the important role of children on organic pesticide adoption as expected. The positive sign of the estimates of all non-adopters except "not applicable", imply non-adoption is more likely than adoption when households have at least one child under 12. The negative sign of non-adopters of "not applicable" supports some studies in the literature (Davis et al., 1992; Alumai et al., 2009) when the reason for "not applicable" is that the households are currently do not treat their lawns. However, since all of these estimates are statistically not significant, child factor still is not clear as the literature figured out (Boizot-Szantai et al., 2017).

Interestingly, the study supports environmental concerns regarding local excessive pesticide use, perception of neighbors' opinion regarding nice lawn, and gardener's behavior as determinants of organic pesticide adoption in lawn care management. It can be seen from the estimation results that the coefficient estimates of "not problem or slight problem" for all non-adopters are significantly positive implying residents concerned with the local excessive use of pesticides as "serious problem" rather than "not/ slight problem" are more likely to be adopters of organic pesticides. The estimate of "never heard" is the biggest: 2.9, followed by "not applicable": 1.7, "know somewhat": 1.5 and "know well": 1.1 respectively. Thus, we have $e^{1.1} = 3$ and $e^{2.9} = 18$ implying the lowest and the highest probability for residents to be non-adopters of "know well" and "never heard" relative to adopters respetively when concerning excessive use of pesticides as "not/ slight problem" rather than "severe problem". In other words, the relative risk ratio of being in the adopter category would be from 3 to 18 times more likely for more serious environmental concerns with respect to non-adopters know organic pesticides well and non-adopters who had never heard of them, respectively. Hinkson Creek has experienced water pollution for a long time, and residents there are very concerned about water quality (Radeke et al., 2001) which is possibly negatively affected by excessive pesticide use. Surprisingly "know well" group has the smallest magnitude among various types of non-adopters, which may originate from organic pesticides is not the safest choice relative chemical ones from "know well" people's perspectives.

For perception of neighbors' opinions regarding nice lawn, almost estimates are significantly positive except one of "never heard" group, which implies residents who strongly agree neighbors' opinions regarding their nice lawn are more likely to be non-adopters rather than adopters. The greater the agreement with their neighbors about appearance of lawn, the greater the chances to fall in non-adopter groups rather than adopter group. The effect is linear since the variable "perception of neighbors' opinions regarding nice lawn" is measured by a Likert scale. The linear effect of the variable in "know well" group is the biggest: 0.429 versus 0.376 of "know somewhat" and 0.352 of "not applicable". In term of the relative probability, people who know organic pesticides well agreed with neighbor's aesthetic concern are more likely to be non-adopters by $e^{.429} = 1.54$ compared to the cases of non-adopters of people know somewhat, $e^{.376} = 1.46$, and people who are not applible using organic pesticides, $e^{352} = 1.42$. Since organic pesticides are seen to be less effective than chemical ones regarding nice lawn, one may ask a question whether the biggest estimate for "know well" group originate from the fact that people in this group give lower credits to organic pesticides than ones in "know somewhat" and "not applicable".

Considering two features of gardener's behavior measured in ordered categorical way, there are significant linear effect for monthly hours spent on lawn care, and cubic effect for weed density. On the other hand, the third dimension in term of hiring pest control companies does not significantly affect adoption. For time feature, estimates of all types of non-adopters are significantly negative implying people who spend more time on lawn care are more likely to be adopters vs. non-adopters. The linear effect of ordered factor is coefficient estimate when comparing two any interval time period (doubles this estimate when considering 0-5 hours and 11-15 hours and so on). We can see the linear effect of the "know well" group is the smallest while one of "never heard" group is the biggest among the results of non-adopters in term of magnitude, (-0.771) versus (-2.345), which may imply the probability of people using less time on lawn care falls into “never heard” group is higher than one falls into “know well” group: .463 versus .096, with respect to the adoption group for example. This may be explained by “never heard” people think bigger substitution effect of organic pesticides for labor yard work than “know well” people do. For the volume of yard work feature, only cubic effect in the model of “know well” non-adopters relative to adopters is significantly negative. The cubic effect means people have smaller volume of work in term of no weed rather than high weed density (> 40 weeds per yard square) are less likely to be non-adopters of “know well” relative to adopters. In other words, even though people know about organic pesticides, if they have to face a high weed density like more than 40 weeds per square yard relative to no weed, they are more likely to be non-adopter rather than adopter of organic pesticides used in lawn care management.

5. Conclusions, implications, and limitations

The main objective of the paper is to examine determinants of household’s adoption of organic pesticide as a best management practice in lawn care using a unique dataset from Missouri. In particular, the paper built a set of factors possibly affecting organic pesticide adoption based on synthesizing the literature of both organic consumption and organic and IPM production, organic cleaning products and organic lawn care practices in general. A possible set of predictors for adoption behavior contains demographic variables, environmental knowledge and attitudes, expectations of property value, and gardener’s behaviors. The role of children, environmental attitudes, perception of neighbors’ opinions, time and yard work are factors of interest. The paper employed a multinomial logit model to test significant factors of the adoption compared to different types of non-adoption with revealed preference assumption.

Overall, the estimation results support some of our hypotheses. For child factor, the paper fails to detect a significant effect on adoption, however this is in line with previous studies (Janssen, 2018, Boizot-Szantai et al., 2017). On the other hand, environmental attitudes, perception of neighbors’ opinions, time and yard work are critical factors even though their effects may be different considering types of non-adopters. Many differences come with “never heard” and “know well” group. For environmental concerns, people who have more concerns with local extensive of chemical use are more likely to be organic pesticide adopters. The biggest effect is of “never heard” group while the smallest one is of “know well” group, implying different environmental knowledge and attitudes between these two groups toward local issues affecting the relative probabilities relative to adopters. For perception of neighbors’ opinions, residents who are more concerned about neighbor's views regarding their lawn appearance are more likely to adopt conventional pesticides rather than organic ones. Effectiveness of organic pesticides compared to synthetic ones may be key reason behind this conclusion, and people know well organic pesticides have motivations to choose conventional pesticides over organic ones when their higher expectations for aesthetic values than the adopters' ones. For gardener behaviors, homeowners who spent more time of gardening per month are more likely to be organic pesticide adopters in lawn care management. As the same as environmental attitude's effect, the biggest effect is of "never heard" group while the smallest one is of "know well" group. The gap herein may come from different views of substitution effect of organic pesticides for labor yard work: people know well about organic pesticides may think they require more labor while "never heard" seem to be overestimate substitutability of organic pesticides. Another dimension of gardener's behavior like yard work in term of average number of weeds may be helpful when choosing no weed case rather than high weed density: people know well about organic pesticides are more likely to be non-adopters than adopters. Again, "know well" people may be concerned about the effectiveness of organic pesticides for weed control.

Based on the results, several implications are drawn regarding gardeners, pest control companies, and environmental policy makers. First, effectiveness of organic pesticides is important to gardeners, comparing to chemical ones, and this is more important to residents who focus on lawn's aesthetic value rather than environmental concerns. Improvements of studies or reports on effectiveness of both commercial and home-made organic pesticides will benefit these residents and pest control businesses. On the other hand, development of gardeners' communications to transfer experiences using organic pesticides effectively may increase adoption. Second, locally environmental concerns are more important than general environmental ones to increase support for safer pesticide practices. This drives the approach of policy makers in dealing with pesticide issues. Financial incentives alone or environmentalism alone might not be effective. The policies might focus on three attributes: cost, value (effectiveness), and "environmental quality" (reduced negative impacts on environmental and personal health). Third, the significant differences between types of non-adopters imply the important role of knowledge on the adoption or non-adoption of organic pesticides. Since pesticides are complicated, "know well" is certainly better than know "somewhat" or "never heard". Another policy implication is commercial organic pesticide labelling need to be improved so that "know somewhat" people become "know well" ones, and social media or other communications help "never heard" people know about this.

These above results are found by the unregularized MNL model in this study. The model fits well and the study provides important evidence for identification of factors affecting organic pesticide adoption in residential lawn care management. However, some of its weaknesses must be noted to understand the limitations of the predictive power of the model, as well as the possible improvements. Two main caveats must be mentioned. One is related to "not applicable" choice which we really do not know what pesticide management practices are currently used in the residential lawn care management. Since this option takes 24.3% of the total sample, treating them as missing will result in a loss of information. In this study we used revealed preference assumption to guarantee this choice as a distinct category of non-adopters. However, we have to keep in mind that there are the cases in which respondents are not applicable since they do not make decisions using organic pesticides, but pest control companies do instead. These cases should be excluded out from the sample since they do not describe exactly homeowner's decision. This fact is source of potential biasedness as well as potential error classification.

Another caveat is that we cannot have better clarification for motivations of time spent on lawn care. Time can be used as a substitute input for pesticides in pest control in the model of household production and consumption. On the other hand, time gardening also represents the enjoyment of gardening, which might be correlated with safer pesticides as the literature indicates. In both cases, more time leads to reduced synthetic pesticides and vice versa. However, we do not know what the motivations are for time spent on lawn care. They might be availability of time because of retirement, or preferences toward nice lawn, or simply hobby or natural exercise and so on. These factors also can affect pesticide use in different ways causing potential biasedness. Note that we are assuming a linear function without interaction effects of random utility for the MNL model, a more complex model might be necessary to avoid omitting important variables like interaction effect or to correct functional form of the random utility. To overcome these caveats, further research is needed to compare people who seem to not use any pesticides versus those that use organic ones. Additional research might explore the link between time spent gardening, motivations for yardwork and the adoption process.

References

1. Adwood D. and Paisley-Jones C. (2017). Pesticides Industry Sales and Usage 2008 - 2012 Market Estimates. U.S. Environmental Protection Agency Washington, DC 20460.
2. Alumai A., Salminen S.O., Richmond D.S., Cardina J. & Grewal P.S. (2009). Comparative evaluation of aesthetic, biological, and economic effectiveness of different lawn management programs. *Springer Science + Business Media, LLC.*
3. Asif M., Xuhui W., Nasiri A., Ayyub S. (2018). Determinant Factors Influencing Organic Food Purchase Intention and the Moderating Role of Awareness: A Comparative Analysis. *Food Qual. Prefer*, 63: 144–150.
4. Bahlai C.A., Xue Y., McCreary C.M., Schaafsma A.W., and Hallett R.H. (2010). Choosing Organic Pesticides over Synthetic Pesticides May Not Effectively Mitigate Environmental Risk in Soybeans. PLoS ONE 5(6): e11250. https://doi.org/10.1371/journal.pone.0011250
5. Baker S., Thompson K. and Engelken J. (2004). Mappingthe values driving organic food choice. *European Journal of Marketing*, Vol. 38 No. 8: 995-1012
6. Beedell J. and Rehman T. (2000). Using Social-Psychology Models to Understand Farmers' Conservation Behavior. *Journal of Rural Studies*, 16: 117-127.
7. Ben-Akiva M. E. and Lerman S. R. (1985). Discrete Choice Analysis: Theory and Application to Travel Demand. Cambridge: MIT Press.
8. Blaine T.W., Clayton S., Robbins P. & Parwinder G.S. (2012). Homeowner Attitudes and Practices Towards Residential Landscape Management in Ohio, USA. *Springer Science+Business Media, LLC.*
9. Boizot-Szantai C., Hamza O., and Soler L. G. (2017). Organic consumption and diet choice:An analysis based on food purchase data in France. *Appetite*, 117: 17-28. http://dx.doi.org/10.1016/j.appet.2017.06.003. PMid:28603060.
10. Boccaletti S. and Nardella M. (2000). Consumer willingness to pay for pesticide-free fresh fruit and vegetables in Italy. *International Food and Agribusiness Management Review 3:* 297–310.
11. Bond C.A., Thilmany D. and Bond J.K. (2008). What to choose? The value of label claims to fresh produce consumers. *Journal of Agricultural and Resource Economics*, Vol. 33: 402-427.

12. Brehm, J.M., D.K. Pasko, and B.W. Eisenhauer (2013). Identifying Key Factors in Homeowner's Adoption of Water Quality Best Management Practices. *Environmental Management* 52 (1): 113–122.
13. Cohen P. (2018). National Gardening Survey, 2018 edition. GardenResearch.com.
14. Constance D.H. and Choi J.Y. (2010). Overcoming the Barriers to Organic Adoption in the United States: A Look at Pragmatic Conventional Producers in Texas. *Sustainability* 2:163-188.
15. Davis J.R., Brownson R.C. & Garcia R. (1992). Family pesticide use in the home, garden, orchard, and yard. *Arch. Environ. Contam. Toxicol*. 22: 260.
16. Dreezens E., Martijin C., Tenbult P., Kok G. and Vries N.K. (2005). Food and values: an examination of values underlying attitudes toward genetically modified and organically grown food products, *Appetite*, 44: pp 115-122.
17. Ellis W.B. and Bradley M.F. (1996). The organic gardener's handbook of natural insect and disease control. Rodale Press, Inc.
18. Genius M., Pantzios C.J. and Tzouvelekas V. (2006), "Information acquisition and adoption of organic farming practices", *Journal of Agricultura1 and Resource Economics*, Vol. 31 No. 1: 11-21.
19. Gomiero T. (2018). Food quality assessment in organic vs. conventional agricultural produce: Findings and issues. *Applied soil ecology*, 123: 714-728. doi: 10.1016/j.apsoil.2017.10.014
20. Greene C. and Kremen A. (2003) US Organic Farming in 2000-2001: Adoption of Certified Systems. Agriculture Information Bulletin No. 780, United States Department of Agriculture, Washington DC.
21. Grob A. (1995). A structural model of environmental attitudes and behaviou. *Journal of Environmental Psychology*. Volume 15, Issue 3:209-220.
22. Gudade B.A., Chhetri P., Gupta U., Deka T.N., Vijayan A.K. and Bhattarai N.K. (2014). The study of ecofriendly practices of large cardamom cultivation in Sikkim and Darjeeling. *Ecology*, Environment and Conservation 20(1): 119-123.
23. Hasan A., Wang Z. and Mahani S.A. (2016). Fast Estimation of Multinomial Logit Models: R Package mnlogit. *Journal of Statistical Software.* Volume 75, Issue 3. DOI: 10.18637/jss.v075.i03

24. Huang C.L. (1996). Consumer preferences and attitudes towards organically grown produce. *European Review of Agricultural Economics*. 23(3-4): 331-342.
25. Hughner R. S., McDonagh P., Prothero A., Shultz C. J., and Stanton J. (2007). Who are organic food consumers? A compilation and review of why people purchase organic food. *Journal of Consumer Behaviour*, **6**(2–3): 94– 110. https://doi.org/10.1002/cb.210
26. Janssen M. (2018). Determinants of organic food purchases: Evidence from household panel data. *Food Quality and Preference* 68: 19–28
27. Jin S., Bluemling B., Mol A. (2015). Information, trust and pesticide overuse: Interactions between retailers and cotton farmers in China. *NJAS - Wageningen Journal of Life Sciences* 72–73: 23–32.
28. Jolly D. A. (1991). Differences between buyers and non-buyers of organic produce and willingness to pay organic price premiums. *Journal of Agribusiness*.
29. Kenedy P. (2003). A Guide to Econometrics 5th edition. Cambridge: MIT Press.
30. Krokopy L.S., Floress K., Klotthor-Weinkauf D., & Baumgart-Getz A. (2008). Determinants of agricultural best management practice adoption: Evidence from the literature. *Journal of Soil and Water Conservation*, 63(5), 300–311.
31. Laferriere K.A., Crighton E.J., Baxter J., Lemyre L., Masuda J.R. & Ursitti F. (2016) Examining inequities in children's environmental health: results of a survey on the risk perceptions and protective actions of new mothers, *Journal of Risk Research*, 19:3, 271-287
32. Law N., Band L. and Grove M. (2004). Nitrogen input from residential lawn care practices in suburban watersheds in Baltimore county, MD. *Journal of Environmental Planning and Management*, 47:5: 737-755.
33. Lea E. and Worsley T. (2005) Australians' organic food beliefs, demographics and values. *British Food Journal*, 107(11): 855-869.
34. Li J., Zepeda L. and Gould B.W. (2007). The Demand for Organic Food in the U.S.: An Empirical Assessment. *Journal of Food Distribution Research*. 38.
35. Lichtenberg E. (2004). Cost-Responsiveness of Conservation Practice Adoption: A Revealed Preference Approach. *Journal of Agricultural and Resource Economics* 29(3): 420-435.
36. Lockie S., Lyons K., Lawrence G., & Mummery K. (2002). Eating green: Motivations behind organic food consumption in Australia. *European Society for Rural Sociology, 41(1)*: 23-40.

37. Luce R.D. (1959). Individual Choice Behaviour: A Theoretical Analysis. John Wiley & Sons, New York.
38. Magnusson M., Arvola A., Hursti U., Aberg L. and Sjoden, P. (2001) Attitudes towards organic foods among Swedish consumers. *British Food Journal*, 103(3): 209-226.
39. Magnusson M., Arvola A., Hursti U., Aberg L. and Sjoden, P. (2003). Choice of Organic Food Is Related to Perceived Consequences for Human Health and to Environmentally Friendly Behaviour. Appetite. 40. 109-17. 10.1016/S0195-6663(03)00002-3.
40. Makatouni A. (2002). What motivates consumers to buy organic food in UK? Results from a qualitative study. *British Food Journal*. 104(3/4/5): 345-352.
41. Marshall S., Orr D., Bradley, L., and Moorman C. (2015). A Review of Organic Lawn Care Practices and Policies in North America and the Implications of Lawn Plant Diversity and Insect Pest Management. *HortTechnology*. 25(4).
42. Moser K. A., (2016). Consumers' purchasing decisions regarding environmentally friendly products: An empirical analysis of German consumers. *Journal of Retailing and Consumer Services, Elsevier*, vol. 31(C): 389-397.
43. McCann L. and Shin D.W. (2018). Household Use of Composted Manure and Phosphorous-Free Fertilizers: Feeling Good versus Doing Good. *Journal of Environmental Protection*, 9: 140-157.
44. McFadden D. (1974). Conditional logit analysis of qualitative choice behavior. In Frontiers in Econometrics, ed. P. Zarembka, New York: Academic Press, 105.42.
45. Meehan T. D., Werling B. P., Landis D. A. and Gratton C. (2011). Agricultural landscape simplification and insecticide use in the Midwestern United States. *Proc. Natl Acad. Sci. USA* **108** 11500–5
46. Nassauer J. I., Wang Z. and Dayrell E. (2009). What will the neighbors think? Cultural norms and ecological design. *Landscape and Urban Planning*, 9: 282-292
47. Ngobo P. V. (2011). What Drives Household Choice of Organic Products in Grocery Stores? *Journal of Retailing 87: 90–100*
48. Padel S. and Foster C. (2005). Exploring the gap between attitudes and behavior: Understanding why consumers buy or do not buy organic food. *British Food Journal*, 107, 8: 606-625

49. Philbert A., Lyantagaye S. and Nkwengulila G. (2014) A Review of Agricultural Pesticides Use and the Selection for Resistance to Insecticides in Malaria Vectors. *Advances in Entomology*, **2**: 120-128. doi: 10.4236/ae.2014.23019.

50. Radeke A.H., Nilon C., and Rikoon J.S. (2001). Factors Affecting Landowner Participation in Ecosystem Management: A Case Study inSouth-Central Missouri. Wildlife Society Bulletin (1973-2006), Vol. 29, No. 1: 195-206.

51. Radman M. (2005). Consumer consumption and perception of organic products in Croatia. *British Food Journal*, 107(4): 263-273.

52. Reimer A.P. and Prokopy L.S. (2012). Environmental Attitudes and Drift Reduction Behavior among Commercial Pesticide Applicators in a U.S. Agricultural Landscape. *Egyptian Journal of Environmental Management*, 113: 361-369. http://dx.doi.org/10.1016/j.jenvman.2012.09.009

53. Riar A., Mandloi L. S., Poswal R. S., Messmer M. M. and Bhullar G. S (2017). A Diagnosis of Biophysicaland Socio-Economic FactorsInfluencing Farmers' Choice to Adopt Organic or Conventional Farming Systems for Cotton Production. *Front. Plant Sci*. 8:1289. doi: 10.3389/fpls.2017.01289

54. Robbins P. and Sharp J. (2003). The Lawn-Chemical Economy and Its Discontents. *Antipode*, vol. 35, issue 5: 955-979.

55. Rogers, E.M. (2010). Diffusion of Innovations (5th edition). Simon and Schuster.

56. Saba A. and Messina F. (2003). Attitudes towards organic foods and risk/benefit perception associated with pesticides. *Food Quality and Preference*, Vol. 14: 637–645.

57. Schäufele I., Pashkova D., and Hamm U. (2018). Which consumers opt for organic wine and why? An analysis of the attitude-behaviour link. *British Food Journal*, Vol. 120 Issue: 8: 1901-1914, https://doi.org/10.1108/BFJ-03-2018-0141

58. Shin D.W. and McCann L. (2017). Enhancing Adoption Studies: The Case of Residential Stormwater Management Practices in the Midwest. *Agricultural and Resource Economics Review*: 1–34.

59. P Singh, Kunwar & Malik, Amrita & Sinha, Sarita. (2007). Persistent Organochlorine Pesticide Residues in Soil and Surface Water of Northern Indo-Gangetic Alluvial Plains. *Environmental monitoring and assessment*. 125. 147-55. 10.1007/s10661-006-9247-0.

60. Straub E.T. (2009). Understanding Technology Adoption: Theory and Future Directions for Informal Learning. *Review of Educational Research*, 79 (2): 625-649.
61. Suh D.H., Khachatryan H. & Guan Z. (2017). Why do we adopt environmentally friendly lawn care? Evidence from do-it-yourself consumers. *Applied Economics*. Vol. 48, No. 27: 2550–2561.
62. Templeton S.R., Yoo S.J. & Zilberman D. (1999). An Economic Analysis of Yard Care and Synthetic Chemical Use: The Case of San Francisco. *Environmental and Resource Economics* 14**:** 385–397.
63. United States Census Bureau (2010). 2010 Census. Available at https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk
64. USDA (1995). USDA National Organic Standards Board (NOSB) definition. https://www.nal.usda.gov/afsic/organic-productionorganic-food-information-access-tools
65. USGS (1999). The United States Geological Survey Report
66. Van Doorn J. and Verhoef P. C. (2015). Drivers of and Barriers to Organic Purchase Behavior. *Journal of Retailing, Elsevier,* vol. 91(3): 436-450.
67. Veldstra M.D., Alexander C.E., and Marshall M.I. (2014). To certify or not to certify? Separating the organic production and certification decisions. *Food Policy* 49: 429–436.
68. Vermeir I. and Verbeke W. J. (2006). Sustainable Food Consumption: Exploring the Consumer "Attitude – Behavioral Intention" Gap. *Journal of Agricultural and Environmental Ethics* 19: 169. https://doi.org/10.1007/s10806-005-5485-3
69. Winterich K. P., Mittal V., and William T. R. (2009), "Donation Behavior toward In-Groups and Out-Groups: The Role of Gender and Moral Identity," *Journal of Consumer Research*, 36 (2): 199–214.