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Factors Influencing Product Liability Insurance Adoption Among Tennessee Fruit and Vegetable Farmers

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I am submitting herewith a thesis written by Matthew Robert Edwards entitled "Factors Influencing Product Liability Insurance Adoption Among Tennessee Fruit and Vegetable Farmers." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

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Factors Influencing Product Liability Insurance Adoption Among Tennessee Fruit and Vegetable Farmers

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ABSTRACT

Foodborne illness outbreaks linked to the consumption of fresh produce expose fruit and vegetable growers to uncertain legal and compensatory costs associated with product liability actions. Product liability insurance protects farmers against the risk of financial loss from product liability actions and may create opportunities for market expansion, but insights from recent focus groups suggest that Tennessee farmers may perceive this insurance coverage as cost prohibitive. This study evaluates the factors influencing adoption of product liability insurance among Tennessee fruit and vegetable producers. Using data from a 2013 survey of Tennessee fruit and vegetable farmers, factors influencing the adoption decision are first evaluated using a single-equation probit regression. Results from the first regression approach suggest that perceptions of product liability risk and acres in fruit and vegetable production are positive determinants of adoption. The model was then expanded to a two-stage probit regression approach to account for simultaneity between adoption of product liability insurance and product liability risk perceptions. Findings from the two-stage regression approach suggest that perception of product liability risk is not a significant determinant of the insurance adoption decision.

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CHAPTER I: INTRODUCTION

Demand for fresh produce has recently increased in the US. In addition to improved year-round availability associated with rising imports, widespread governmental efforts to synthesize an evolving body of knowledge about the health benefits associated with consuming fresh produce is among the key drivers of change (Cook, 2011). Numerous federal programs aim to increase US consumption of fresh produce as a means to combat obesity, which is largely concentrated in the Southeastern states (CDC, 2015). However, concerns over the prevalence of foodborne illness outbreaks related to fresh produce have the potential to deter market growth for fresh fruits and vegetables (Boys, 2013).

Foodborne illnesses affect nearly 48 million people each year in the US (CDC, 2013). Hoffmann, Maculloch, and Batz (2015) estimated that, on average, the annual economic burden imposed by fifteen major foodborne pathogens is $15.5 billion. On the other hand, Scharff (2015) suggested that foodborne illnesses generated an estimated $54.9 billion in health-related costs annually in the US. Between 1998 and 2008, produce accounted for 46 percent of foodborne illnesses and 23 percent of deaths reported to the CDC's Foodborne Disease Outbreak Surveillance System (Painter et al., 2013). DeWaal et al. (2015) linked produce to more foodborne illnesses than any other food group using a compilation of foodborne illness outbreaks reported to the Center for Disease Control and Prevention between 2003 and 2012.

Due to growing concern about food safety issues associated with fresh produce, improving safety throughout the food supply chain has become a national health objective. As a result, food safety regulation in the US has transformed dramatically in recent years. Food safety issues related to fresh produce have also spurred interest in improved traceability, or the ability to track food products "from the grower to the consumer's plate" (Wilson and Clarke, 1998). For

example, following the 2006 *E. coli* outbreak linked to spinach, the farm that produced the contaminated spinach could only be identified after an extensive investigation had taken place, exposing the need for improved traceability in the produce industry (Pouliot and Sumner, 2008). Innovations in traceability systems improve the likelihood of identifying responsible parties in the case of a foodborne illness outbreak, ultimately increasing grower accountability for potential foodborne illness outbreaks (Buzby, Frenzen, and Rasco, 2001). In turn, producers are increasingly susceptible to legal action by consumers claiming monetary damages for illnesses caused by contaminated food products, also called product liability (PL) risk (Rejesus and Dunlap, 2009).

Public and private regulation, monitoring, and enforcement mechanisms designed to reduce the incidence of foodborne illness outbreaks have primarily focused on improving food safety standards (Havinga, 2012). For example, the Food and Drug Administration (FDA) Food Safety Modernization Act (FSMA), which was finalized in November 2015, established the first science-based minimum safety standards for growing, harvesting, packing, and handling fruits and vegetables for human consumption (USFDA, 2016). Unaddressed by new regulations is the extent to which firms are liable for foodborne illness (Boys et al. 2015).

Monetary losses associated with litigation can be sizable. These include costs associated with jury verdicts (i.e., financial compensation to a plaintiff), court costs, and legal fees, the latter of which may be incurred regardless of legal conclusions (Henson and Hooker, 2001). Mahdu (2015) reviewed the outcomes of 511 foodborne illness lawsuits between 1979 and 2014, finding that compensation to successful plaintiffs ranged from $151 to $6.2 million.

Whereas intermediate and retail outlets often place specific PL insurance requirements on their suppliers, direct-to-consumer market outlets generally have less explicit requirements of

this type (Holcomb, Palma, and Velandia, 2013; Velandia et al., 2014). Generally, direct-to-consumer outlets such as farmers markets and Community Supported Agriculture have limited or no requirements specifically associated with PL insurance (Boys, 2013). Findings from a 2011 survey of Tennessee fruit and vegetable producers found that fresh produce growers in Tennessee made nearly 75% of their sales through direct-to-consumer outlets (Wolanin, 2013). Therefore, Tennessee fruit and vegetable producers may be less likely to carry PL insurance than farmers who sell more of their produce through intermediate or retail outlets.

Producers can mitigate their exposure to PL risk through precautionary measures such as third-party audits and/or certifications. Good Agricultural Practices (GAP) certification[1], for example, involves an on-farm audit by a third-party to verify adherence to guidelines or industry-specific protocols upheld by the auditing organization (Rejesus, 2009; Critzer and Wzselaki, 2012). Additionally, compliance with quality assurance standards may serve as a legal defense against claims of negligence (Connally, 2009). While precautionary measures such as GAP compliance reduce the risk of microbial contamination, the economic benefit of reducing microbial risk only accrue to the producer in a fooborne illness outbreak (Rejesus, 2009). Nonetheless, there may be indirect benefits such as access to market outlets requiring this type of certification.

Previous studies have generally evaluated produce farmer perceptions of risk (e.g. Hanson et al., 2004; Ali and Kapoor, 2008; Velandia et al., 2014), and the use of GAP as a risk management strategy among them (Sriwichailamphan et al., 2008; Kersting and Wollni, 2012; Marine et al., 2016). However, less understood are the factors influencing the adoption of PL risk

[1] GAP audits for fresh produce are offered by numerous organizations and vary in scope (Critzer and Wszelaki, 2012), but many organizations, including the USDA Produce GAP audit program, use harmonized standards promoted by United Fresh Produce Association (USDA-AMS, 2015; UFPA, 2016).

management strategies, such as PL insurance (Ivey, LeJeune, and Miller, 2012; Boys, 2013). The objective of this research is to determine the factors influencing the adoption of PL insurance among Tennessee fruit and vegetable producers.

In addition to providing protection against PL risk, PL insurance may be used as a marketing or differentiation strategy (Boys, 2013). Thus, adopting PL insurance may help producers access new market opportunities. Farmer inability to adopt PL insurance may also imply market exclusion and marginalization (Handschuch, Wollni, and Villalobos, 2013). Therefore, understanding the factors influencing the adoption of PL insurance by fruit and vegetable producers is an important step in determining measures that policy makers can implement to equip Tennessee producers with tools necessary to maintain their competitiveness under a new regulatory environment while providing safe products to consumers. This information may also help insurance companies better target producers more likely to adopt PL insurance.

CHAPTER II: LITERATURE REVIEW

Hardaker et al. (2015) refers to 'risk' as exposure to uncertain outcomes. Therefore, by engaging in the production and sale of food products, which are affected by many factors both within and beyond the farmer's control, farmers are exposed to the risk of loss or harm to others. Previous literature provides numerous classifications for the types of risks faced by farmers. Generally, these include production, market, financial, legal, environmental, and human risk (Harwood et al., 1999; Hardaker et al., 2015).

In addition to facing price and production risk, fresh produce growers are exposed to risk related to the perishable nature of fruits and vegetables in addition to PL risk (Ligon, 2001; Martinez et al., 2010). For example, due to the highly perishable nature of fresh produce, fruit and vegetable growers generally have less time to pursue alternate buyers and/or more favorable prices after harvesting their produce (Schieffer and Vassalos, 2015). Many fresh produce growers rely on local direct-to-consumer marketing channels, intermediated channels, or a combination of the two (Low et al., 2015). Direct-to-consumer marketing channels, in particular, may increase producer exposure to PL risk (Dunn, Harper, and Greaser, 2000).

Microbial contamination of fresh produce can occur at any point during production, processing, distribution, or preparation (CDC, 2016). Since fresh fruits and vegetables are often consumed raw with minimal processing, pathogen contamination is an inherent risk faced by produce farmers (Tauxe et al., 1997). Further, producers selling directly to consumers could easily be linked to a contaminated product, decreasing the chances of a legal outcome favoring farmers in the case of PL litigation (Buzby, Frenzen, and Rasco, 2001).

The adoption of risk management tools among US row crop farmers has been intensively studied by agricultural economists, specifically the utilization of risk management tools such as

crop insurance, forward contracting, and spreading sales (Knight et al., 1989; Goodwin and Schroeder, 1994; Mishra and El-Osta, 2002; Sherrick et al., 2004; Velandia et al., 2009). In contrast, research regarding the adoption of risk management tools by fruit and vegetable producers is limited (Hanson et al., 2004; Uematsu and Mishra, 2011; Vassalos and Li, 2016).

Several studies have evaluated the factors influencing the adoption of GlobalGAP and GAP certification[2], while others have focused on the adoption of food safety and quality standards among fruit and vegetable producers (e.g., Sriwichailamphan et al., 2008; Kersting and Wollni, 2012; Handschuch, Wollni, and Villalobos, 2013; Adalja and Lichtenberg, 2015; Marine et al., 2016). In the area of PL risk, there are a few studies that have examined attributes influencing jury verdicts in food product liability lawsuits (Buzby, Frenzen, and Rasco, 2001; Mahdu, 2015). Only one study analyzed the adoption of PL insurance among specialty crop producers (Boys, 2013).

Sriwichailamphan et al. (2008) evaluated the factors influencing GAP adoption among pineapple farmers in Thailand. Their analysis found that adoption of GAP was significantly influenced by age, average price received by farmers, average yield, use of marketing contracts, environmental concerns, buyer requirements, and farmer progressiveness.

Handschuch, Wollni, and Villalobos (2013) examined the adoption of voluntary food safety and quality standards among Chilean raspberry producers. They also evaluated the impact of adoption on farm performance. Their findings suggest that gender, education, farm size, and membership in a farming association affected adoption of voluntary food safety and quality standards. Implementation of these standards was found to positively affect farmer income.

[2] GAP and GlobalGAP certifications are risk management tools that farmers can use to protect their businesses against PL risk.

Marine et al. (2016) used survey data from Maryland and Delaware vegetable growers to evaluate the influence of vegetable acres farmed, farming experience, and market channels used to sell products on the likelihood of adopting various on-farm food safety practices including GAP certification. The authors found that farm size and market channels used to sell produce influenced GAP adoption.

Adalja and Lichtenberg (2015) used data from a national survey of US fruit and vegetable growers to evaluate the influence of farm size and farming practices use on the adoption of food safety measures required by the Food Safety Modernization Act's Standards for the growing, harvesting, packing, and holding of produce for human consumption (i.e., Produce Rule). The study also evaluated differences in costs associated with implementing these food safety measures. After controlling for differences in crop type, marketing channels, and farming practices, they found no significant impact of farm size on the use of the various food safety measures evaluated. In contrast, farm size influenced the cost of complying with food safety measures. Their results suggest that the cost of food safety measures regulated by the FSMA's Produce Rule exhibit economies of scale and support the notion that compliance by smaller firms is more burdensome.

Boys (2013) summarized data from a survey of small- and medium-scale producers located in the southeastern US that evaluated producer motivations and barriers to adopt an insurance providing PL coverage. Buyer requirements, liability concerns, and interest in improving marketing strategies were found to be the main motivations for the adoption of an insurance policy providing PL coverage. Respondents indicated that the benefits of having this type of insurance policy included improved market access, mitigated risk of litigation, and improvements in farm reputation.

The Role of Perceptions of Risk on the Adoption of Risk Management Tools

Several studies have investigated the role of producer perceptions and producer understanding of risk on the adoption of risk management tools (e.g., Boggess, Anaman, and Hanson, 1985; Harwood et al., 1999; Hall et al., 2003; Velandia et al., 2009; Le and Cheong, 2010). In the context of PL risk, Ivey, LeJeune, and Miller (2012) examined vegetable producer perceptions and knowledge about food safety, food contamination, and GAP using data from a survey of vegetable producers located in Ohio, Michigan, Indiana, and Kentucky. Their analysis found that most vegetable producers do not believe contamination is most likely to occur on the farm. However, these producers indicated interest in obtaining information about sources of product contamination and GAP guidelines.

CHAPTER III: CONCEPTUAL FRAMEWORK

Foodborne illnesses linked to the consumption of fruits and vegetables expose producers to the risk of financial loss associated with product liability actions. Producer i has initial wealth of w, but runs the risk of losing L dollars when facing a lawsuit for illness or death associated with the production and sale of contaminated products (Mas-Colell, Whinston, and Green, 1995). The probability of producer i incurring loss L, which encompasses compensatory costs to victims, court costs, and legal fees, is denoted by p. The probability of loss is assumed to be a function of farm-specific factors including, but not limited to, sales volume, type of produce farmed and sold, and management practices (e.g., GAP certification). If no contamination occurs, the producer's wealth is unaffected. If contamination resulting in foodborne illness and/or death occurs, but a consumer of the contaminated product does not seek compensation from the court system, producer i's wealth also remains unchanged. Using a von Neumann-Morgenstern expected utility function (Mas-Colell, Whinston, and Green, 1995) producer i's expected utility function is

(1) $$U(w) = (1 - p)u(w) + pu(w - L).$$

Consider the availability of insurance with premium π, which is assumed to be a function of producer *i*'s gross annual sales (Spilker, 2015). The indemnity amount I is paid by the insurance provider for actual economic losses incurred by producer i. Pursuant to the insurance contract, the insurance provider agrees to indemnify losses incurred by the producer up to a specified level of coverage, q, such that $I \leq q$. Producer's i expected wealth when PL insurance is purchased is $w - \pi$. In contrast, producer i's wealth when loss L occurs is $w - \pi - L + I$. Producer i's expected utility of being insured is

(2) $$U_I(w) = (1 - p)u(w - \pi) + pu(w - \pi - L + I);$$

$$\text{s.t. } I < L.$$

Subtracting equation (1) from (2) results in

$$\Delta U = U_I(.) - U(.). \tag{3}$$

Assuming producer i makes decisions consistent with maximizing his or her expected utility over wealth, the producer will adopt PL insurance if $\Delta U > 0$, or where the expected utility of adopting insurance exceeds the expected utility of not adopting insurance such that $U_I(.) > U(.)$. Since ΔU is unobservable, producer i's decision to purchase PL insurance, y, is modeled as a dichotomous variable, such that

$$y = \begin{cases} 1 \; if \; \Delta U > 0 \\ 0 \; if \; \Delta U \leq 0 \end{cases}. \tag{4}$$

Product Liability Insurance and State Contingent Benefits

It can be shown that producer i's expected utility of adopting insurance depends on the realization of loss. First, consider the case where loss L is realized. Factoring out the probability of loss, p, from equation (3) leads to

$$p[u(w - \pi - L + I) - u(w - L)]. \tag{5}$$

Hence, if L is realized, the producer benefits from purchasing PL insurance only if $I > \pi + L$. If no loss occurs, $1 - p$ can be factored out of equation (3):

$$(1 - p)[u(w - \pi) - u(w)]. \tag{6}$$

Therefore, if insurance is purchased and no loss occurs, the insurance premium, π, accrues to the producer as a negative benefit and, thus, PL insurance would not be preferred.

CHAPTER IV: DATA AND EMPIRICAL MODEL

Data

Data for this study was obtained from a mail survey of Tennessee fruit and vegetable producers conducted in 2013. The sample consisted of 495 fruit and vegetable producers listed in the Tennessee Department of Agriculture's Pick Tennessee Products program website (TDA, 2015). On April 1, 2013, the first survey mailing was distributed along with a cover letter explaining the purpose of the study and a prepaid return envelope. Postcard reminders were sent out on April 19, 2013, followed by a final wave of mailings to producers who had not yet completed the survey on April 29, 2013. Of the 495 surveys mailed, 163 were completed and returned. Out of 163 returned surveys, 18 responses were from producers who either no longer produce and/or sell fruits and/or vegetables, or farmers who produce fruits and vegetables solely for personal consumption. These observations were eliminated, resulting in a usable response rate of 29.3% (145).

Survey respondents were introduced to the concept of PL insurance as an instrument that could help protect producers by limiting the extent of their exposure to risk associated with consumer claims of injury caused by harmful or contaminated products. The survey included questions about producer risk perceptions, familiarity with and use of risk management tools including PL insurance, cost and level of coverage associated with PL insurance, reason for not using PL insurance, sources of information about PL insurance, and general farm operator and farm business characteristics (see survey instrument in Appendix B).

Secondary data on county-level characteristics was obtained from the 2012 Census of Agriculture (USDA-NASS, 2012). Age distributions of fruit and vegetable growers were used to determine the extent to which the sample was representative of the population under

consideration. The number of farms with vegetables, potatoes, and melons harvested for fresh market was also obtained for use in the regression models.

Empirical Model

Socioeconomic and demographic factors that influence risk attitudes may also affect risk management decisions, such as the choice to purchase crop insurance (Smith and Baquet, 1996). Hence, previous literature evaluating the factors influencing risk attitudes and risk management adoption decisions served as natural starting points to identify which variables to include in the adoption equations.

Age, experience, and educational attainment have been considered by several studies as potential determinants of risk management decisions (e.g., Shapiro and Brorsen, 1988; Smith and Baquet, 1996; Mishra and El-Osta, 2002; Sherrick et al., 2004; Mohammed and Ortmann, 2005; Bukenya and Nettles, 2007; Sriwichailamphan et al., 2008; Velandia et al., 2009; Uematsu and Mishra, 2011).

More experienced farmers may be more likely to anticipate risks associated with producing and marketing agricultural products and, thus, more likely to use strategies such as insurance to manage risk (Sherrick et al., 2004; Velandia et al. 2009). However, experienced farmers may be more diversified in their portfolios, better able to self-insure against losses, and wealthier (Smith and Baquet, 1996). If so, more experienced farmers may be less likely to adopt insurance to manage risk, particularly if they have taken alternative measures to manage risk. For example, Mohammed and Ortmann (2005) found that older, more experienced farmers were less likely to purchase livestock insurance. The authors suggested that more experienced farmers may have accumulated enough knowledge over time to cope with income variability without

insurance (Mohammed and Ortmann, 2005). Experience (EXP) is hypothesized to be negatively correlated with PL insurance adoption.

Smith and Baquet (1996) and Mishra and El-Osta (2002) found that education is positively correlated with the adoption of crop insurance. Educational attainment may augment a farmer's ability to gather information about his or her risk exposure, including the potential consequences of adverse outcomes (Mishra and El-Osta, 2002). Thus, education (COLLEGE) is expected to positively influence the adoption of PL insurance. Further, education may be correlated with wealth through its effect on off-farm wages (Mishra and El-Osta, 2002). Without an alternative measure of financial leverage, such as the debt-to-asset ratio (e.g., Velandia et al. 2009), wealth may otherwise be difficult to adequately control for.

The extent to which producers are liable for damages caused by defective products varies from state to state (Buzby, Frenzen, and Rasco, 2001). In Tennessee, a producer who abides by federal or state statutes or administrative regulations "prescribing standards for design, inspection, testing, manufacture, labeling, warning, or instructions for use of a product" is able to raise a rebuttable presumption that the product was not in an unreasonably dangerous condition at the time of production[3]. Thus, a producer who demonstrates compliance with GAP standards, which are based on federal guidelines designed to prevent foodborne illness outbreaks, not only mitigates the risk of such an event occurring, but also reduces the likelihood of being found guilty if a foodborne illness outbreak is linked to any product from his/her farm (Connally, 2009). Thus, it is hypothesized that GAP certified and/or trained producers (GAP) are less likely to adopt an insurance product providing PL coverage.

[3] Tennessee Code, Product Liability Actions - Tennessee Code Annotated (TCA) § 29-28-104.

Several studies have examined the influence of farm size and gross farm sales on the adoption of agricultural risk management strategies (e.g., Knight et al., 1989; Mishra and El-Osta, 2002; Velandia et al., 2009; Uematsu and Mishra, 2011). Larger firms have a greater capacity to absorb costs associated with a risk management strategy, particularly if these costs have a relatively large fixed cost component. For example, Marine et al. (2016) found that larger vegetable farms are more likely to implement GAP than smaller farms. Farm size and farm sales may also reflect levels of risk exposure both in terms of the likelihood of occurrence and the amount of assets at risk. Thus, an increase in acres in fruit and vegetable production (ACRE) is hypothesized to have a positive effect on the probability of adopting PL insurance.

Demand for insurance is expected to be greater for producers who face a higher likelihood of exposure to insurable risk (Sherrick et al., 2004). Risk exposure has been measured by variables indicating whether a farm produces fruits and vegetables that are considered “high risk” (i.e., fresh produce that is highly susceptible to contamination). It is hypothesized that producers growing high-risk products (CANTALOUPE, LETTUCE) are more likely to adopt PL insurance (Redman, 2007). Growers of “high-risk” products may be more likely to take actions to protect themselves from potential adverse outcomes associated with selling contaminated products. For example, Velandia et al. (2014) found that farmers who produce high-risk fruits and vegetables, such as lettuce and cantaloupes, are less likely to overlook PL risk.

Risk preferences are also important factors to consider when evaluating the decision to adopt insurance products (Petrolia, Landry, and Coble, 2013; Botzen and van den Bergh, 2012). Previous studies have employed several methods measure individual risk attitudes. For example, Petrolia, Landry and Coble (2013) incorporated experiment-based measures of risk aversion into their model of flood insurance adoption via a real-money experiment, whereby survey

respondents make pairwise choices between possible risks of loss and chances of gains. The authors found that their measure of risk aversion to loss was positively correlated with the decision to adopt flood insurance (Petrolia, Landry, and Coble, 2013). Botzen and van den Bergh (2012), who also focused on flood insurance adoption decisions, included an explanatory variable representing the use of alternative insurance policies by an individual as an indicator of revealed risk attitudes. Their findings suggested that the indicator of revealed risk preferences was significant and positively correlated with the decision to adopt flood insurance (Botzen and van den Bergh, 2012). In this analysis, variables indicating producer use of strategies other than PL insurance were incorporated as proxies of risk preference. The alternative strategies considered relate to personal and business risks faced by farmers. It is hypothesized that the extracted factors (FACTOR1, FACTOR2) will be positively correlated with the probability of adopting PL insurance.

Overstreet, Cegielski, and Hall (2013) suggest that attitude and social pressure (e.g., interaction-driven norms) are strongly correlated with the adoption of preventative innovations that do not provide immediate benefit. However, as noted by Marra, Pannell, and Ghadim (2003), theoretical and empirical literature often fails to adequately consider the influence of risk, uncertainty, and learning as attitudes that may be the result of an individual mindset or social pressure on adoption decisions. An example of individual mindset or social pressure characteristics that could influence adoption decisions is perceptions of risk, defined as the awareness of PL risk as a risk faced when selling produce for human consumption. It is hypothesized that a producer who is aware of PL risk associated with selling fruits and vegetables (RISKP) may be more likely to adopt PL insurance.

Finally, using results from a study evaluating small and medium scale (SMS) producer motivations and barriers to purchase food PL insurance, Boys (2013) note that buyer requirements and interest in improving marketing strategies influence producer decisions to purchase PL insurance. Producers making a greater percentage of their sales through direct-to-consumer outlets generally face less stringent requirements related to PL insurance. Thus, it is hypothesized that an increase in the percentage of sales made through direct-to-consumer outlets (DIRECT) will negatively correlate with the probability adopting PL insurance.

CHAPTER V: ESTIMATION METHODS

Probit Regression

The insurance adoption decision is modeled as a random utility function (Greene, 2003). Underlying the observed adoption decision, y, in equation (4) is the unobservable latent variable ΔU, which represents the propensity to adopt PL insurance. Stated differently, ΔU is the excess utility of adopting this risk management tool (Rabe-Hesketh and Skrondal, 2012). The latent variable ΔU in equation (3) is hypothesized to be a function of exogenous covariates, x, such that

(7) $$\Delta U = x'\beta + \varepsilon,$$

where β is a vector of parameters to be estimated, and ε is a random disturbance term. Combining the relationship between the observed choice, y, in equation (4) and the latent variable, ΔU, in equation (3), the probability of adopting PL insurance is defined as

(8) $$\begin{aligned} &\Pr(y = 1|x) = \Pr(\Delta U > 0 \mid x); \\ &= \Pr(x'\beta + \varepsilon > 0 \mid x); \\ &= \Pr(\varepsilon > -x'\beta \mid x); \\ &= F(x'\beta), \end{aligned}$$

where $F(\cdot)$ is the cumulative distribution function of ε (Cameron and Trivedi, 2010). A standard normal distribution (i.e. $\mu = 0$ and $\sigma^2 = 1$) is assumed, thus a probit regression is used in the analysis:

(9) $$\Pr(\Delta U > 0 \mid x) = \Pr(y = 1 \mid x) = F(x'\beta) = \Phi(x'\beta),$$

where $\Phi(\cdot)$ is the standard normal cumulative distribution function. The corresponding log likelihood function is

(10) $$\ln L = \sum_{i=1}^{N} [yln\,\Phi(x'\beta) + (1 - y)\ln\{1 - \Phi(x'\beta)\}].$$

Marginal Effects of Continuous and Discrete Explanatory Variables

The marginal effect of a continuous variable is

$$\frac{\partial E[y \mid x]}{\partial x} = \left\{\frac{d\Phi(x'\beta)}{d(x'\beta)}\right\}\beta = \phi(x'\beta)\beta, \tag{11}$$

where $\phi(\cdot)$ is the standard normal density corresponding to the cumulative distribution $\Phi(\cdot)$. For the case of a dummy variable, the marginal effect is

$$\Pr[\bar{x}_{(d)}, d = 1] - \Pr[\bar{x}_{(d)}, d = 0], \tag{12}$$

where $\bar{x}_{(d)}$ represents the mean values of all other covariates in the model (Greene, 2003).

Two-Stage Simultaneous Probit Regression

In the case of PL insurance adoption, there may be factors that influence the adoption decision which are simultaneously determined with the adoption decision itself. Assuming that perceptions of PL risk influence producer decisions to adopt PL insurance, and it may be the case that the adoption of PL insurance influences producer perceptions of PL risk. For example, farm and farmer characteristics have been found to influence farmer adoption of risk management tools (Velandia et al., 2009; Akinola, 2014), and farmer risk perception (Dosman, Adamowicz, and Hrudey, 2001); Velandia et al., 2014). Thus, if perception of PL risk is simultaneously determined by PL insurance adoption, then the variable representing perception of risk is generally correlated with the disturbance term, ε.

The consistency of maximum likelihood (ML) estimators from the probit regression rests on the assumption that all explanatory variables included in the model are uncorrelated with the error term. If this assumption fails (i.e., one of the explanatory variables is correlated with ε), the ML estimator does not converge in probability to the population parameter as the sample size grows to infinity (Wooldridge, 2003). In the case that perception of PL risk and adoption of PL

insurance are jointly determined, one possible estimation method for addressing simultaneity between two dichotomous variables is the two-stage simultaneous probit regression (Maddala, 1983). The two-equation model is

(13) $$\Delta U = \gamma_1 y_2^* + \beta_1' x_1 + \varepsilon_1,$$

(14) $$y_2^* = \gamma_2 \Delta U + \beta_2' x_2 + \varepsilon_2,$$

(15) $$y_2 = 1[y_2^* > 0],$$

where y_2^* is the latent variable associated with the observed indicator of perception of PL risk, y_2, and ΔU is the latent variable underlying the observed adoption decision, y, in equation (4). Additionally, x_1 and x_2 are exogenous variables; β_1, β_2, γ_1 and γ_2 are vectors of parameters to be estimated; and ε_1 and ε_2 are random disturbance terms. The reduced forms of (13) and (14) are

(16) $$\Delta U = \Pi_1 X + v_1,$$

(17) $$y_2^* = \Pi_2 X + v_2,$$

where X includes all exogenous variables in x_1 and x_2. Because y_2^* and ΔU are only observed as dichotomous variables y_2 and y, respectively, and $Var(v_1) = \sigma_1^2$ and $Var(v_2) = \sigma_2^2$, it is only possible to estimate Π_1/σ_1 and Π_2/σ_2. Nonetheless, given that σ_1^2 and σ_2^2 are normalized to one:

(18) $$\Pi_1/\sigma_1 = \Pi_1,$$

(19) $$\Pi_2/\sigma_2 = \Pi_2.$$

A necessary and sufficient condition for the identification of equation (13) is that the number of exogenous variables that appear in equation (14) must be at least as large as the number of endogenous variables included in (13), also called the order condition (Mallar, 1977; Wooldridge, 2002; Greene, 2012). Table 6 presents an overview of the model specifications and depicts variable exclusions in each model.

After estimating the reduced form equations by probit maximum likelihood, the predicted values of y_2^* and ΔU are substituted in equations (13) and (14), respectively, and then the structural equations are estimated using maximum likelihood.

In the procedure, the estimated standard errors of the structural equations are based on the fitted values of the endogenous variables, $\Delta\widehat{U}$ and $\hat{y}_2^*$, whereas the true variables are ΔU and y_2^*. Therefore, adjusted asymptotic covariance should be used. The adjusted asymptotic covariance matrices of the structural equations (13) and (14) follow

(20) $$\alpha_1' = (\gamma_1, \beta_1'),$$

(21) $$\alpha_2' = (\gamma_2, \beta_2'),$$

(22) $$a_1 = \frac{\phi_1}{\Phi_1(1-\Phi_1)},\ a_2 = \frac{\phi_2}{\Phi_2(1-\Phi_2)},$$

(23) $$A_1 = \phi_1 a_1,\ A_2 = \phi_2 a_2,\ Z = \begin{bmatrix} \Pi_2^* X \\ X \end{bmatrix},$$

(24) $$W_1 = \frac{1}{N} \sum_1^N A_1\, ZZ',$$

(25) $$W_2 = \frac{1}{N} \sum_1^N A_2\, XX',$$

(26) $$W_3 = \frac{1}{N} \sum_1^N A_1\, (\gamma_1) ZX',$$

(27) $$W_4 = \frac{1}{N} \sum_{\prime}^N a_1 a_2\, E[(y_1 - \Phi_1)(y_2 - \Phi_2)] XZ',$$

where ϕ_1 and ϕ_2 are the standard normal probability density functions associated with the estimated latent variables ΔU and y_2^* from the reduced form equations (16) and (17) ; Φ_1 and Φ_2 are the cumulative distribution functions associated with ΔU and y_2^*; and $\Pi_2^* X$ is the estimated vector for y_2 obtained from equation (17) (Maddala, 1983). The covariance matrix is calculated as

(28) $$W_1^{-1}[W_1 - W_3 W_2^{-1} W_4 - W_4' W_2^{-1} W_3' + W_3 W_2^{-1} W_3'] W_1^{-1},$$

where α_{01} is the true value of α_1 and $\widehat{\alpha}_1$ is the two-stage estimator. Similarly, the covariance matrix of $\widehat{\alpha}_2$ is computed by interchanging subscripts 1 and 2 in the definitions of Z , W_1, W_2, W_3, and W_4.

Hausman Specification Test of Endogeneity

A Hausman specification test was performed to test the null hypothesis that perceptions of PL risk are exogenous in PL insurance adoption decisions. Estimates from the two-stage simultaneous probit regression can be compared to the estimates produced by the single-equation probit regression that ignored simultaneity. The Hausman statistic is

(29) $$H = (\beta_C - \beta_E)'(V_C - V_E)^{-1}(\beta_C - \beta_E),$$

where β_C and β_E are parameter estimates from the single-equation and two-stage simultaneous equation, respectively, and V_C and V_E are their respective covariance matrices of.

Under the null hypothesis, the Hausman statistic, H, is distributed χ^2 with k degrees of freedom, where k equals the number of being evaluated (Hausman, 1978). If adoption of PL insurance and perceptions of PL risk are simultaneously determined, the parameter estimates from the probit regression model in equation (9) are inconsistent and the null hypothesis will be rejected.

Instrumental Variables Probit Regression

It is also possible that endogeneity exists due to omitted variables (Wooldridge, 2002). In this case, the structural-model approach may be used (Cameron and Trivedi, 2010). Under the structural-model approach, the latent variable ΔU in equation (7) is the dependent variable, while y_2 denotes the endogenous regressor. The latent variable ΔU is modeled as a function of exogenous variables, x_1, and the endogenous variable, y_2, such that

(30) $$\Delta U = \gamma_2 y_2^* + \beta_1' x_1 + \epsilon_1,$$

(31) $$y = 1[\Delta U > 0],$$

where γ_1 and β_1 are vectors of unknown parameters associated with y_2 and x_1, respectively, and ϵ_1 is a random disturbance term. The continuous endogenous regressor y_2^* is modeled as a function of exogenous variables, x_1, and additional instrumental variables, x_e, such that

(32) $$y_2^* = \pi_1' x_1 + \pi_2' x_e + \epsilon_2,$$

where π_1 and π_2 are vectors of parameters to be estimated and ϵ_2 is a random disturbance term.

Equation (30) is the structural equation, and (32) is the reduced form equation. The vector of instrumental variables, x_e, must include variables that are correlated with y_2^*, but not correlated with ΔU in equation (30). Assuming that the error terms (ϵ_1, ϵ_2) are jointly normally distributed and that $Var(\epsilon_1) = 1$,

(33) $$\epsilon_1 \mid \epsilon_2 = \rho\epsilon_2 + u,$$

where ρ represents the correlation coefficient for (ϵ_1, ϵ_2), and u is a disturbance term independent from x_1, x_e, ϵ_2, and therefore y_2^* (Wooldridge, 2002). Under the null hypothesis that $\rho = 0$, ϵ_1 and ϵ_2 are independent. Rejecting the null hypothesis indicates that y_2^* is indeed endogenous. The variable of interest is adoption of PL insurance. Predicted values of perception of PL risk from the reduced form in equation (32) are substituted into the structural equation in (30).

Factor Analysis of Alternative Risk Management Strategies Used by Producers

Factor analysis is commonly used to examine the underlying structure of observed (i.e., manifest) variables and to reduce the dimensionality of a set of manifest variables (Yong and Pearce, 2013). Motivating the decision to conduct a factor analysis is the assumption that there exists underlying latent constructs which explain the covariation in a set of manifest variables (O'Rourke and Hatcher, 2013).

In their examination of the influence of message framings and food safety-related media information on consumer risk perceptions of *E. coli* infection and their attitude towards food safety technology, Britwum and Yiannaka (2016) used factor analysis to reduce the dimensionality of responses pertaining to consumer trustworthiness rating for information from institutions and acceptance ratings of non-conventional food production processes. Oliver (2016) utilized factor analysis to identify underlying latent constructs related to farmer attitudes associated with the adoption of a hypothetical prescribed grazing program, which were captured in ratings of importance and potential outcomes measured via a 5-point Likert scale.

In this study, factor analysis was used to examine the patterns underlying producer use of risk management strategies other than PL insurance (Table 1), which serve as a proxy of producer risk attitudes (Botzen and van den Bergh, 2012). If manifest variables are dichotomous in nature, the common factor model, which assumes a linear relationship between manifest variables and factors, can generate biased estimates (Matsunaga, 2010; Flora, LaBrish, and Chalmers, 2012). This issue is addressed by estimating the relationship between latent constructs underlying a set of observed dichotomous variables with a tetrachoric correlation matrix (MacCallum et al., 2002). Proposed by Pearson (1900), the tetrachoric correlation is estimated by assuming a latent bivariate normal distribution for a pair of dichotomous variables, then estimating the correlation between the underlying continuous variables as if they could be observed (Greene, 2003).

For each pair of binary survey items (v_1, v_2), which are assumed to have a bivariate normal distribution associated with their latent components (X_1, X_2) with threshold model $v_i = 1$ if $X_i > 0$, the tetrachoric correlation coefficient r is estimated from the joint distribution of v_1 and v_2 (Tallis, 1962). Pairwise estimates of the tetrachoric correlations yield the tetrachoric

correlation matrix for use in the factor analysis procedure. The m-factor model with n manifest variables is

$$x_n = \lambda_{nm} F_m + e_n, \tag{34}$$

where F_m is a vector of latent factors, x_n is a vector of manifest variables loading onto the mth factor, e_n is a vector of measurement error, and λ_{nm} is a matrix containing factor loadings of the nth manifest variable on the mth factor (Yong and Pearce, 2013). Factor loadings indicate the correlation between the common factor and the manifest variables, and, thus, reflect the amount to which a variable contributes to the factor (Kline, 1994; Yong and Pearce, 2013).

The literature offers varying recommendations as to what constitutes an adequate sample size for factor analysis (Williams, Onsman, and Brown, 2010). Some recommendations pertain to the number of respondents per variable included in the factor analysis, referred to as the subject-to-item ratio and denoted by $N\colon p$. Costello and Osborne (2005), who examined 303 research articles that utilized either principal components analysis or exploratory factor analysis, found that over 60 percent of the sampled studies using these techniques had a subject-to-item ratio of at least 10:1. Other recommendations are concerned with the minimum sample size necessary to obtain stable factors, which vary from 100 to 250 observations (Hogarty et al. 2005). The $N\colon p$ ratio of the factor analysis model in this study is 17.5:1. The 105 observations are within the minimum range suggested in the literature (Hogarty et al., 2005).

Prior to the extraction of factors, the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was used to determine the suitability of the data for factor analysis. The overall KMO index compares the sum of squared correlations of all variables with the sum of squared partial correlations between pairs of variables i, j, controlling for the effects of remaining variables. The KMO index is

(35) $$KMO = \frac{\sum_S r_{ij}^2}{\sum_S \left(a_{ij}^2 + r_{ij}^2\right)},$$

where $S = (i, j; i \neq j)$, r_{ij} denotes the correlation of variables i and j, and a_{ij} denotes the anti-image correlation (Kaiser, 1974). Models with an overall KMO index of 0.5 or less are considered unsuitable for factor analysis (Kaiser, 1974). The overall KMO index of the model in this study is 0.62.

The variance explained by an extracted factor is referred to as the eigenvalue of that factor. To aid in determining the appropriate number of factors to retain, a scree plot was generated by graphing the eigenvalues associated with a factor in descending order against the factor number (Figure 1). The scree "test" involves visually examining the scree plot to identify the natural break point in the data (Torres-Reyna, 2012). Once a break is identified, the researcher retains the number of factors n that lie above the natural break point (i.e., $n - 1$), such that, if the natural break point appears at $n = 5$, then 4 factors are retained (Costello and Osborne, 2005).

The scree plot from the factor analysis procedure revealed the presence of a natural breaking point around $n = 2$, suggesting the retention of one factor. Under the Kaiser criterion, which suggests retaining only those factors with eigenvalues greater than one, only the first factor would be retained (Costello and Osborne, 2005). However, the criteria used to determine the number of factors to retain are not steadfast, often requiring the researcher to use his or her best judgement (Matsunaga, 2010).

A one-factor model was examined, yielding relatively large uniqueness values and indicating that the variables were not well-explained by the single factor (Torres-Reyna, 2012). Moreover, the eigenvalue of the second factor (0.85) was relatively close to the Kaiser criterion

cutoff of one. Based on these findings, the decision was made to retain two factors, which explained 63 percent of the total variance (Table 2).

Factor loadings were rotated simplify the factor analysis output and to facilitate interpretation of factor loadings (Thompson, 2004). Whereas orthogonal rotation assumes that factors are uncorrelated, oblique rotation allows correlation between factors. Because risk management decisions are expected to be correlated across different domains (Einav et al., 2010), oblique promax rotation was used.

The variable indicating farmer use of savings (SAV) had a uniqueness value of 0.68, thus the variable was removed and treated as a standalone variable. The factor analysis was performed on the remaining four variables and rotated using promax rotation. Two factors surfaced from the final analysis (Table 3). Variables that loaded onto Factor 1 were farmer use of a commercial business insurance policy (COMB) and farm-structure as a corporation or Limited Liability Corporation (LLC). Factor 1 was interpreted as 'Business-oriented Farmers'. Variables that loaded onto Factor 2 were farmer use of a comprehensive liability insurance policy (CLIAB) and farmer use of a homeowner's insurance policy (HOWN). Factor 2 was interpreted as 'Community-oriented Farmers'. Producer use of an umbrella insurance policy (UMB) loaded onto Factors 1 and 2.

The factor score coefficients relating the indicator variables to the extracted factors are shown in Table 3. Each factor is expressed as a linear combination of the standardized indicator variables. Factors 1 and 2 are computed as:

$$F_1 = -0.0198 \cdot CLIAB + 0.5403 \cdot COMB - 0.0015 \cdot HOWN + 0.2088 \cdot UMB + 0.2732 \cdot LLC, \tag{36}$$

and

(37) $$F_2 = 0.3561 \cdot CLIAB - 0.1501 \cdot COMB - 0.3072 \cdot HOWN + 0.3860 \cdot UMB + 0.1038 \cdot LLC,$$

where CLIAB indicates farmer use of a comprehensive farm liability insurance policy; COMB indicates farmer use of a commercial business insurance policy; HOWN indicates farmer use of a homeowner's insurance policy; UMB indicates farmer use of an umbrella insurance policy; and LLC indicates a farm structured as a corporation or Limited Liability Corporation (LLC).

Comparison of Sample Means

Characteristics of adopters and non-adopters were compared to evaluate differences in characteristics between the two population subsets and to gain insight into the factors influencing the adoption decision. Prior to employing *t* tests, an *F* test was used to compare the variances of variables between the two subsets (Snedecor and Cochran, 1989). Next, *t* tests, assuming equal or unequal variances depending on the outcome of the *F* test, were used to compare variable means for farm, farmer, and county characteristics described above between adopters and non-adopters.

Multicollinearity Tests

Condition indexes were used to detect collinear relationships between explanatory variables used in the regressions (Belsley, Kuh, and Welsch, 1980). Condition indexes were evaluated to detect the presence of values exceeding the chosen threshold of 30. Threshold values generally range from 15 to 30, with 30 being a commonly used value (Hair et al., 1998). If a condition index larger than the threshold value was identified, the variable was examined to identify variance proportions above 90 percent. A condition index that exceeds the threshold value and accounts for a proportion of variance of 90 percent or above for two or more coefficients indicates multicollinearity (Hair et al., 1998).

CHAPTER VI: RESULTS AND DISCUSSION

Evaluation of Data

Sample descriptive statistics and hypothesized signs are presented in Table 4. Comparing the survey sample data to data from the 2012 Census of Agriculture is a useful strategy to provide insight into the extent to which the survey sample is representative of Tennessee fruit and vegetable producers (Figure 3). Farmers in the 25 to 34 and 55 to 64 age categories are slightly overrepresented in the survey sample, and middle-aged farmers (35 to 54 years old) are slightly underrepresented compared to the 2012 Census of Agriculture. Overall, the average age of the sample is slightly less than the average age of principal operators of Tennessee farms according to the 2012 Census of Agriculture, which is 59.2 (USDA-NASS, 2012).

Sample Means Comparison

Results from the comparison of characteristics between adopters and non-adopters of PL insurance indicate that producers who adopted PL insurance coverage had more acres in fruit and vegetable production (Table 5). A greater proportion (78%) of adopters acknowledged facing PL risk when selling fruits and vegetables compared to the proportion of non-adopters who indicated perceiving this risk (59%) (see question 17, Appendix B). Adopters operated larger fruit and vegetable operations (26 acres) than non-adopters (7 acres).

Probit Regression Results

Single-equation probit regressions were estimated separately for the adoption of PL insurance and the perception of PL risk equations. Parameter estimates and marginal effects associated with explanatory variables included in the single-equation adoption model are shown in Table 7. Condition indexes were under 20, thus multicollinearity was not likely to hinder interpretation of parameter estimates. The likelihood ratio test, which tests the null hypothesis

that all regression coefficients were simultaneously equal to zero, was significant at the 5% level. Thus, the null hypothesis that all coefficients were simultaneously equal to zero was rejected, suggesting significance of the overall model. The model correctly predicted 70% of responses.

Perception of PL risk (RISKP) and acres in fruit and vegetable production (ACRE) positively affected the adoption of PL insurance coverage, consistent with the hypothesized signs. The marginal effect for the perception of PL risk indicates that perceiving PL risk increases the probability of adoption by 21%. A one-acre increase in fruit and vegetable production corresponds to a 0.7% increase in the probability of adoption. Years of experience farming (EXP), educational attainment (COLLEGE), cantaloupe production (CANTALOUPE), lettuce production (LETTUCE), percentage of sales made through direct-to-consumer market outlets (DIRECT), use of alternative risk management tools (FACTOR1 and FACTOR2), use of savings to manage risk (SAV), and GAP training and/or certification (GAP) did not significantly affect the probability that a farmer adopted PL insurance coverage.

Two-Stage Probit Regression Results

Parameter estimates and marginal effects associated with explanatory variables included in the simultaneous equation probit regressions are presented in Table 8. Condition indexes were examined for the the equations (13) and (14). Condition indexes remained below 20 for each set of explanatory variables, providing no indication that multicollinearity was an issue. The null hypothesis that all coefficients were simultaneously equal to zero was tested for each model using likelihood ratio tests. With respect to the reduced form equations, the null hypothesis that all coefficients were simultaneously equal to zero was rejected at the 10% and 5% level for the adoption and perception models, respectively, suggesting weak significance of the overall models, at best. With respect to the structural equations, the null hypothesis that all coefficients

were simultaneously equal to zero was rejected at the 10% level for the adoption and perception models, suggesting weak significance of the overall models.

The Hausman specification test was used to test the null hypothesis that perceptions of PL risk are exogenous in PL insurance adoption decisions (Table 9). The null hypothesis was not rejected at any conventional level ($\chi^2 = 13.63$, with P = 0.254, df = 11), suggesting that the single-equation models may not be incorrectly specified.

Instrumental Variables Probit Regression Results

The instrumental variables probit regression was estimated to test for endogeneity due to measurement error. Parameter estimates and marginal effects associated with explanatory variables included in the IV probit model are shown in Table 10. The null hypothesis that all regression coefficients were simultaneously equal to zero was rejected at the 1% level ($\chi^2 = 54.34$, df = 11), suggesting significance of the overall model. Of interest was the Wald χ^2 test of exogeneity, which was used to test the null hypothesis that correlation coefficient in equation (33) was equal to zero. The null hypothesis could not be rejected at any conventional level ($\chi^2 = 0.57$, with P = 0.45, df = 1). These findings provide insufficient evidence to conclude that perception of PL risk is endogenous due to omitted variables.

CHAPTER VII: CONCLUSIONS

This study builds on previous agricultural risk management research by analyzing the factors influencing PL insurance adoption among Tennessee fruit and vegetable growers. The adoption decision was modeled as using a standard probit regression model. Findings suggest that farmers who perceived PL risk and farmers with larger fruit and vegetable operations were more likely to adopt PL insurance.

One limitation of the study is that it made strong distributional assumptions about the error terms used in the modeling approach. Semi-nonparametric methods have been used to address this very issue (e.g., Velandia et al., 2014), which, if incorrectly specified, yields inconsistent estimates. A second limitation of the study relates to the framing of the study. To clarify, the approach considered PL insurance solely as a risk management tool. Although it briefly discussed the benefits of PL insurance in terms of market opportunities, the role which benefits to market access play in the adoption decision may be significant.

As this research serves merely as a building block, a worthy next step is to analyze the distributional assumptions on which the model is based on. If the assumption about normality of the error terms is not valid, maximum likelihood estimates would be unreliable. Thus, a semi-nonparametric approach, such as that taken by Velandia et al. (2014), is a natural starting point for expanding on the foundations established in this paper.

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APPENDICES

APPENDIX A

TABLES

Table 1. Description and Means of Alternative Risk Management Indicator Variables Used in the Factor Analysis

Variable	Description	Mean (N = 105)
SAV	Equals one if the farmer uses or has used financial savings and zero otherwise	0.4286
CLIAB	Equals one if the farmer uses or has used a comprehensive farm liability insurance policy and zero otherwise	0.3238
COMB	Equals one if the farmer uses or has used a commercial business insurance policy and zero otherwise	0.1333
HOWN	Equals one if the farmer uses or has used a homeowner's insurance policy and zero otherwise	0.4952
UMB	Equals one if the farmer uses or has used an umbrella insurance policy and zero otherwise	0.2381
LLC	Equals one if the farm is structured as a corporation or Limited Liability Corporation and zero otherwise	0.1524

Table 2. Eigenvalues and Proportion of Variance Explained by Retained Factors

Factor	Eigenvalue	Difference	Proportion	Cumulative
FACTOR1	2.276	1.423	0.455	0.455
FACTOR2	0.853	0.821	0.171	0.626
N	105			
LR $\chi^2(10)$ [ab]	236.95***			

[a] Likelihood ratio test of independent versus saturated model.
[b] Significance at the 1% level denoted by ***.

Table 3. Rotated Factor Loadings and Uniqueness Values for Alternative Risk Management Strategies

Variable[a]	Factor Loading		Uniqueness
	Factor 1	Factor 2	
CLIAB	-0.068	0.760	0.458
COMB	0.923	-0.133	0.226
HOWN	-0.047	0.728	0.494
UMB	0.530	0.460	0.318
LLC	0.753	0.086	0.376

[a] Variables are defined in Table 1.

Table 4. Variable Definitions, Means, and Hypothesized Signs

Variable	Definition	Mean	SD	Min	Max	Hypothesized Sign
PINS	Equals one if the farmer carries product liability insurance coverage and zero otherwise	0.35	0.48	0.00	1.0	
RISKP	Equals one if the farmer perceives product liability risk and zero otherwise	0.66	0.48	0.00	1.0	+
EXP	Experience farming in years	23.36	16.14	1.00	70.0	−
COLLEGE	Equals one if the farmer earned Bachelor or Graduate degree and zero otherwise	0.53	0.50	0.00	1.0	+
ACRE	Average fruit and/or vegetable acreage grown in 2011 and 2012	13.87	32.01	0.13	214.0	+
CANTALOUPE	Equals one if the farmer produced cantaloupes and zero otherwise	0.27	0.44	0.00	1.0	+
LETTUCE	Equals one if the farmer produced lettuce and zero otherwise	0.29	0.45	0.00	1.0	+
DIRECT	Percentage of sales made through direct-to-consumer market outlets	89.15	24.67	0.00	100.0	−
FACTOR1	Business-oriented farmer (extracted Factor 1)	0.17	0.30	-0.00	1.04	+
FACTOR2	Community-oriented farmer (extracted Factor 2)	0.36	0.36	-0.15	1.15	−
GAP	Equals one if farmer is Good Agricultural Practices trained and/or certified and zero otherwise	0.29	0.45	0.00	1.0	−
FMFARMS	Number of operations with vegetables harvested for fresh market in farmer's county	16.94	11.46	1.00	84.0	
N	105					

Table 5. Comparison of Characteristics between Product Liability Insurance Adopters and Non-Adopters

Variable[a]	Adopter Mean	Non-Adopter Mean	t statistic[bc]
RISKP	0.7838	0.5882	-2.04**
EXP	25.8108	22.0294	-1.15
COLLEGE	0.5405	0.5294	-0.11
ACRE	25.6149	7.4760	-2.16**†
CANTALOUPE	0.2703	0.2647	-0.06
LETTUCE	0.3243	0.2647	-0.64
DIRECT	85.8696	90.9277	1.00
FACTOR1	0.2414	0.1297	-1.87*
FACTOR2	0.3838	0.3395	-0.60
GAP	0.3243	0.2647	-0.64
N	37	68	

[a] Variables are defined in Table 4.
[b] Significance at the 10% and 5% levels denoted by * and **, respectively.
[c] T-test assuming unequal variance denoted by †.

Table 6. Two-Stage Simultaneous Probit Regression Model Specification

Exogenous variables	Equation 13 Adoption (PINS)	Equation 14 Perception (RISKP)
EXP	✓	✓
COLLEGE	✓	✓
ACRE	✓	✓
CANTALOUPE	✓	✓
LETTUCE	✓	✓
DIRECT	✓	✓
CAUTION	✓	✗
GAP	✓	✗
FMFARMS	✗	✓

Note: The symbol ✓ indicates that a variable was included in an equation; the symbol ✗ indicates exclusion from an equation.

Table 7. Parameter Estimates and Marginal Effects of Independent Variables on the Probability of Adoption of Product Liability Insurance Using Probit Regression

Variable[a]	Coefficient[bc]	Marginal Effect
RISKP	0.6742**	0.2134
	(0.3227)	
EXP	0.0086	
	(0.0101)	
COLLEGE	-0.1148	
	(0.2813)	
ACRE	0.0196**	0.0062
	(0.0097)	
CANTALOUPE	-0.2864	
	(0.3386)	
LETTUCE	0.3408	
	(0.3538)	
DIRECT	0.0041	
	(0.0069)	
FACTOR1	0.8037	
	(0.4981)	
FACTOR2	0.0186	
	(0.4417)	
SAV	-0.1987	
	(0.3150)	
GAP	-0.0746	
	(0.3579)	
CONSTANT	-1.6602**	
	(0.7874)	
N	105	
LR $\chi^2(11)$[d]	19.32**	
AIC[e]	140.95	
Correctly predicted	74 (70%)	

[a] Explanatory variables are defined in Table 4.
[b] Standard errors shown in parentheses.
[c] Significance at the 5% level denoted by **.
[d] Likelihood ratio test statistic is calculated as LR = $-2[\ln L_R - \ln L_U]$ (Cameron and Trivedi, 2010).
[e] Akaike information criterion calculated as AIC = $-2\ln L + 2K$ (Greene, 2012).

Table 8. Parameter Estimates and Marginal Effects of Independent Variables on the Probability of Adoption of Product Liability Insurance and Probability of Identifying Product Liability Risk from Two-stage Simultaneous Probit Regression

	Adoption (PINS=1)		Perception of Risk (RISKP=1)	
Variable[a]	Coefficient[bc]	Marginal Effect	Coefficient[bc]	Marginal Effect
RISKPHAT	1.1047			
	(1.9079)			
PINSHAT			0.7995**	0.3598
			(0.3843)	
EXP	0.0088		-0.0075	
	(0.0172)		(0.0112)	
COLLEGE	-0.3951		0.3334	
	(0.3788)		(0.3337)	
ACRE	0.0246		-0.0215***	-0.0080
	(0.0266)		(0.0063)	
CANTALOUPE	-0.7264		0.6835	
	(0.5567)		(0.4237)	
LETTUCE	-0.2058		0.3969	
	(0.7159)		(0.4848)	
DIRECT	0.0052		-0.0104	
	(0.0102)		(0.0080)	
FACTOR1	-0.0057			
	(1.2319)			
FACTOR2	0.1811			
	(0.6154)			
SAV	-0.7394*	-0.2408		
	(0.4393)			
GAP	-0.3443			
	(0.4902)			
FMFARMS			-0.0033	
			(0.0143)	
CONSTANT	-1.1101		1.7397*	
	(1.9079)		(0.9013)	
N	105		105	
LR $\chi^2(11/8)$	15.9*		13.84*	
AIC	138.27		137.01	
Correctly predicted	73 (69.2%)		74 (70.4%)	

[a] Independent variables are defined in Table 4. PINSHAT and RISKPHAT are predicted values from equations (13) and (14), respectively.
[b] Corrected standard errors shown in parentheses.
[c] Significance at the 10%, 5%, and 1% levels denoted by *, **, and ***, respectively.

Table 9. Results from Hausman Specification Test

Null hypothesis	Hausman χ^2 test statistic	*df*	*P*-value
Correct specification of single-equation probit regression predicting adoption (PINS)	13.6301	11	0.2541

Table 10. Parameter Estimates and Marginal Effects of Independent Variables on the Adoption of Product Liability Insurance Using Instrumental Variables Probit Regression

Variable[a]	Coefficient[bc]	Marginal Effect
RISKP[d]	2.1627**	0.2009
	(0.8915)	
EXP	0.0045	
	(0.0107)	
COLLEGE	-0.2383	
	(0.2449)	
ACRE	0.0150	
	(0.0135)	
CANTALOUPE	-0.3948	
	(0.2909)	
LETTUCE	-0.0871	
	(0.5436)	
DIRECT	0.0032	
	(0.0062)	
FACTOR1	0.2097	
	(0.8717)	
FACTOR2	0.0844	
	(0.3853)	
SAV	-0.4603	
	(0.2955)	
GAP	-0.1959	
	(0.3126)	
CONSTANT	-1.8268**	
	(0.8296)	
N	105	
Wald test of exogeneity: $\chi^2(1)$	0.57	
Wald $\chi^2(11)$	54.34***	
AIC	290.57	
Correctly predicted	74(70.4%)	

[a] Explanatory variables are defined in Table 4.
[b] Standard errors shown in parentheses.
[c] Significance at the 5% and 1% levels denoted by ** and ***, respectively.
[d] FMFARMS used as instrument.

FIGURES

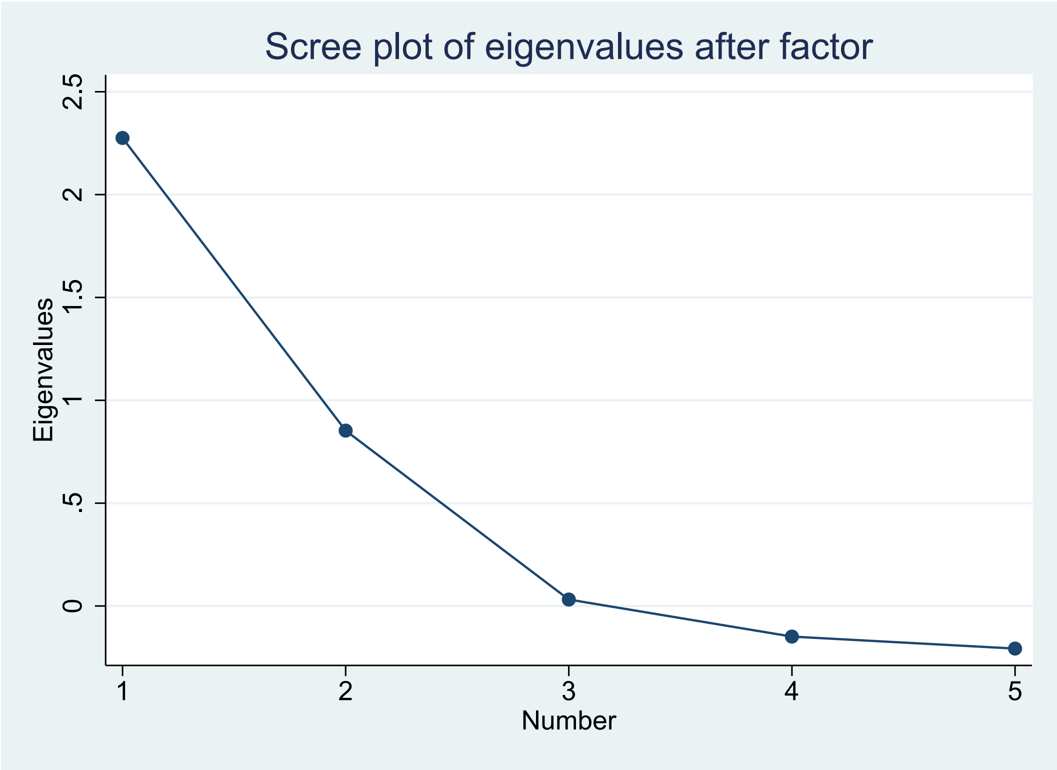

Figure 1. Scree Plot of Eigenvalues from Factor Analysis

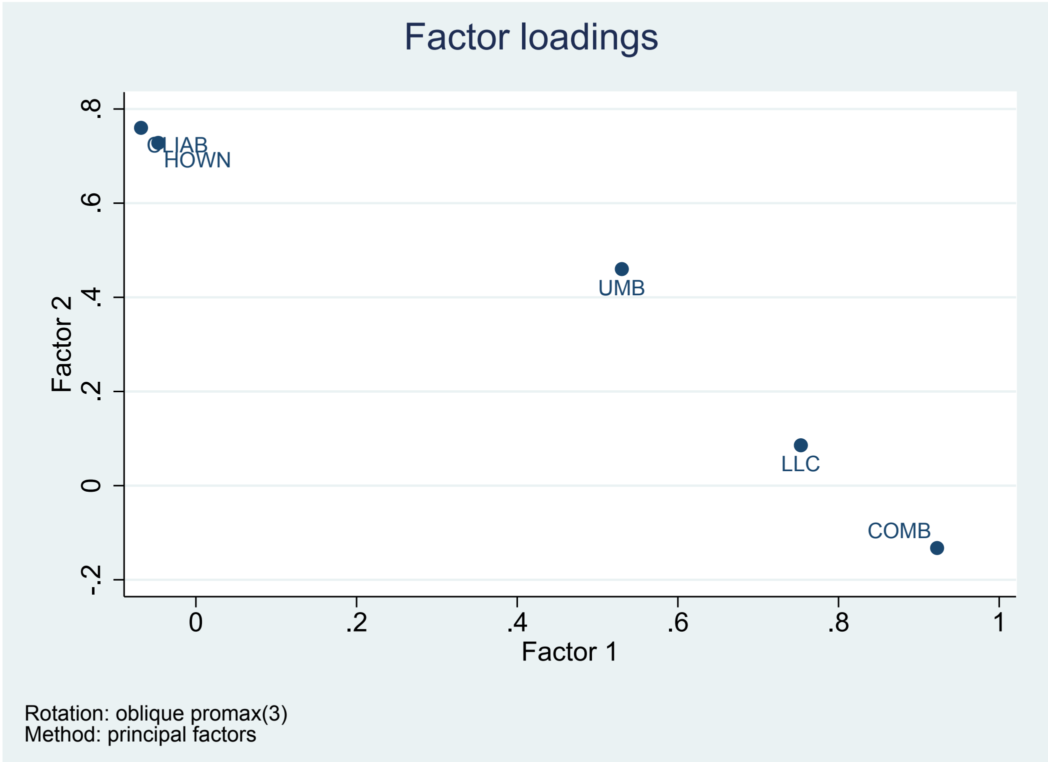

Figure 2. Rotated Factor Loading Plot from Factor Analysis Procedure

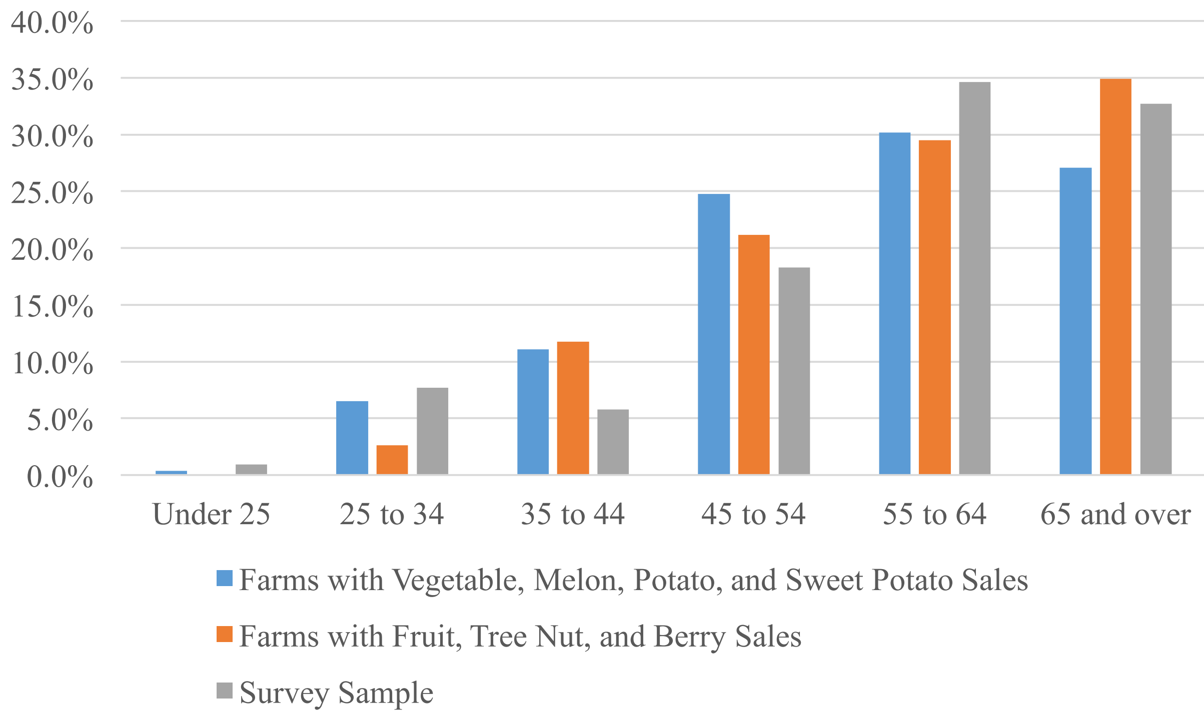

Figure 3. Comparison of Age Distribution of Survey Sample and Tennessee Fruit and Vegetable Farmers Reported in 2012 Census of Agriculture

APPENDIX B

THE UNIVERSITY of TENNESSEE

INSTITUTE of AGRICULTURE

2013 TENNESSEE FRUIT & VEGETABLE PRODUCER SURVEY

*** Product Liability Risk ***

Fruit and vegetable growers face important risks associated with foodborne illness outbreaks. Two examples are:

1) Liability risks in that consumers can take legal actions against producers demanding monetary compensation claiming the food they purchased made them sick.

2) Regulators can issue a product recall or warning because of a foodborne illness outbreak that can cause an enormous drop in product sales and an economic loss for all producers including those whose product was not contaminated.

Product liability insurance may help protect producers by limiting their possible exposure to risks associated with consumers' claims of injury caused by harmful or contaminated products. Other insurance products may help producers cover direct and indirect costs associated with product recalls. Researchers at the University of Tennessee request your help in completing the attached survey to design educational tools that help growers understand product liability risks and how to protect against these risks.

The enclosed 7-page survey should take about 20 to 25 minutes to complete. This survey is being sent to a random sample of 700 Tennessee fruit and vegetable producers. The survey is funded by the USDA Specialty Crop Block Grant and is conducted as part of a research and outreach project in cooperation with the Tennessee Department of Agriculture. Your participation is strictly voluntary, and your response to this survey will be confidential. Responses to the survey will be aggregated and published in summary form only.

Please complete the survey and mail it back to us in the enclosed self-addressed postage-paid envelope. Your response is extremely valuable, and we look forward to receiving your completed survey. The survey results will be made available at **http://vegetables.tennessee.edu**. Thank you for taking the time to assist the University of Tennessee's Institute of Agriculture with this survey.

*** ***IMPORTANT*** ***

Are you the **best person** to answer questions about fruit and vegetable marketing and product liability on your farm? If so, please answer the following questions. **If not**, please direct this questionnaire to the person who makes the fruit and vegetable marketing decisions. **Please note that questions about your farming operation apply to the 2011 and 2012 crop years.**

A. PLEASE TELL US ABOUT YOURSELF AND YOUR OPERATION

1. In what county is your primary farming operation located?

_________________ County

2. In what year were you born? ____________

3. How many years have you farmed? ________years

4. How many years have you been selling fruits or vegetables? ________years

5. Please indicate your sex (check one)

☐ Male

☐ Female

6. Which of the following describes the highest level of education you have obtained?

☐ Less than High School/GED
☐ High School/GED
☐ Some college
☐ Associate degree or Vocational school or equivalent
☐ Bachelors' degree
☐ Graduate degree

7. How many persons are in your household, including yourself?

☐ 1
☐ 2
☐ 3
☐ 4
☐ 5 or more

8. What is your primary occupation?

☐ Full time farmer
☐ Employed full-time off the farm
☐ Employed part-time off the farm
☐ Retired and farming part-time
☐ Usually employed (full time or part time) off the farm, but currently unemployed

9. On the land you owned or rented from others, how many acres did you use to produce fruits, vegetables, and other crops in the **last two years**?

Fruits, Vegetables, and Other Crops	**2011**		**2012**	
	Acres in Production		**Acres in Production**	
	Owned	Rented	Owned	Rented
Fruits and Vegetables				
Other Crops				

10. Which of the following farm products and services were produced on your farm **in 2012**? ***(Check all that apply).***

PLEASE NOTE THAT "FRESH MARKET SALES" INCLUDES U-PICK FOR THIS SURVEY.

- ☐ Fruits and/or vegetables for *fresh market sales*
- ☐ Fruits and/or vegetables for *processing*
- ☐ Grains
- ☐ Hay
- ☐ Nursery crops, Greenhouse crops, or Christmas trees
- ☐ Nuts
- ☐ Other (*please list)*:________________________
- ☐ Poultry or Eggs
- ☐ Milk
- ☐ Beef
- ☐ Pork
- ☐ Lamb or goat meat
- ☐ Value-added farm products (e.g. ham, wine, cheese)
- ☐ Agri-tourism

B. MARKETING INFORMATION

IF YOU **DID NOT** SELL FRUITS AND VEGETABLES YOU RAISED IN THE LAST TWO YEARS, PLEASE ANSWER "NO" TO ***QUESTION 11*** AND THEN SKIP TO ***QUESTION 27***.

11. Did you sell fruits and/or vegetables that you raised in **2011 or 2012**?

___Yes, ***proceed to Question 12***

___No, ***skip to Question 27***

12. Did you sell fruits and/or vegetables **purchased from someone else in the last two years**?

2011: ____Yes ____ No   **2012**: ____ Yes ____ No

13. Approximately what percentage of your farm's gross annual sales came from *fresh market* sales of fruits and vegetables in the **last two years**? **2011**_______% **2012**_______%

14. Approximately what percentage of your farm's gross annual sales came from sales of fruits and vegetables for *processing* in the **last two years**? **2011** ________% **2012**______%

15. Which of the following fruits and vegetables did you produce for sale (for fresh market sales or for processing) in **the last two years**? ***(Check all that apply).***

☐Apples	☐Grapes	☐Snap Beans
☐Bell peppers	☐Lettuce	☐Squash
☐Blueberries	☐ Greens	☐Strawberries
☐Blackberries	☐Okra	☐Sweet Corn
☐Broccoli	☐Onions	☐Tomatoes
☐Cabbage	☐Peaches	☐Turnips
☐Cantaloupes	☐Pears	☐Watermelons
☐Cherries	☐Plums and prunes	☐ Other fruits__________________
☐Cucumbers and/or Pickles	☐Pumpkins	☐ Other vegetables_____________

16. Mark with an "X" the marketing methods you used in the **last two years** in selling fruits and/or vegetables and estimate the percentage of your sales made through each method. Mark with an "X" those methods you used that require product-liability insurance.

	Marketing methods used (mark with an "X")		**Estimate the percentage of sales made through this method (each column should total 100%)**		**These marketing methods require product liability insurance (mark with an "X")**
Direct Sales to Consumers:	**2011**	**2012**	**2011**	**2012**	
On farm sales					
Farmers' markets					
Community Supported Agriculture (CSA)					
Roadside stands					
Pick-your-own					
Other direct sales(describe) ______________________					
Sales to Intermediaries:					
Grower cooperatives					
Wholesale buyers/brokers/packers					
Other farmers					
Other intermediaries (describe) ________________________					
Sales to Retail Outlets:					
Grocery stores					
Food cooperatives					
Restaurants					
Institutions (such as schools and hospitals)					
Other retail outlets (describe) _______________________					
			100%	100%	

C. RISK MANAGEMENT AND LIABILITY INSURANCE

17. What are the risks you face when selling fruits and/or vegetables? ***(Mark all the risks that apply with an "X").***

Risks	Mark with an "X"
Customer liability associated with injuries caused by harmful products such as contaminated fresh products	
Customer liability associated with bodily injury that occurred on the farm premises	
Product recall or warning because of foodborne illness outbreak	
Low sales volume, unsold produce	
Quality problems with produce due to weather, pests, etc.	
Buyer back out, failure to fulfill commitments	
Market fluctuations (e.g., low price, low profits)	
Other risk (describe) ___________________________	

18. Mark an "**X**" to the left of each risk management option that you use or have used to manage risk in your operation. On a scale from 1 to 7 where "1" is not important and "7" is very important, circle how important you believe each option you marked is in terms of risk management on a typical farm.

Mark an "X" if used	Risk Management Options	Not Important						Very Important
	Financial savings/reserves	1	2	3	4	5	6	7
	Adjusted Gross Revenue (AGR) or Adjusted Gross Revenue-Lite (AGR-lite) crop insurance	1	2	3	4	5	6	7
	Actual Production History or APH insurance (Yield Base Insurance)	1	2	3	4	5	6	7
	Product liability insurance policy	1	2	3	4	5	6	7
	Product recall policy	1	2	3	4	5	6	7
	Comprehensive farm liability policy	1	2	3	4	5	6	7
	Good Agricultural Practices (GAP) training/certification	1	2	3	4	5	6	7
	Commercial business policy	1	2	3	4	5	6	7
	Homeowner's policy	1	2	3	4	5	6	7
	Umbrella policy	1	2	3	4	5	6	7
	Become a corporation or limited liability company (LLC)	1	2	3	4	5	6	7
	Other (describe) __________________________	1	2	3	4	5	6	7

19. On a scale from 1 to 7, where "1" is not familiar and "7" is very familiar, please circle your familiarity with each insurance coverage option for fresh produce growers.

Risk Management Options	Not Familiar 1	2	3	4	5	6	Very Familiar 7
Product liability insurance policy	1	2	3	4	5	6	7
Comprehensive farm liability policy	1	2	3	4	5	6	7
Homeowner's policy	1	2	3	4	5	6	7
Umbrella policy	1	2	3	4	5	6	7
Commercial business policy	1	2	3	4	5	6	7
Product recall policy	1	2	3	4	5	6	7
Adjusted Gross Revenue (AGR) or Adjusted Gross Revenue-Lite (AGR-lite) crop insurance	1	2	3	4	5	6	7
Actual Production History or APH insurance (Yield Base Insurance)	1	2	3	4	5	6	7
Other (describe) ______________________	1	2	3	4	5	6	7

The following definition may be helpful:
Product liability insurance protects producers against consumer claims of injury caused by harmful products such as contaminated fresh or value added products.

20. Do you have insurance that provides product liability coverage?

____ Yes
____ No → In the space below, please indicate the main reasons why you don't have product liability coverage and then ***Skip to Question 27***:

____
____
____

____ I Don't Know → ***Skip to Question 27***.

21. What type of insurance policy do you use to provide product liability coverage?

- ☐ Product liability insurance policy
- ☐ Comprehensive farm liability policy
- ☐ Homeowner's policy
- ☐ Umbrella policy
- ☐ Commercial business policy
- ☐ Other (please describe) ______________________________

22. Check the category that best reflects your product liability insurance coverage.

- ☐ Under $100,000
- ☐ $100,000 - $299,999
- ☐ $300,000 - $599,999
- ☐ $600,000 - $999,999
- ☐ $1 million - $1.9 million
- ☐ $2 million - $2.9 million
- ☐ $3 million - $3.9 million
- ☐ $4 million - $4.9 million
- ☐ $5 million – up

23. Check the category that best reflects the annual cost of your insurance coverage.

- ☐ Under $1,000
- ☐ $1,000 - $1,999
- ☐ $2,000 - $2,999
- ☐ $3,000 - $3,999
- ☐ $4,000 – $4,999
- ☐ $5,000 - up

24. What are the names of the insurance companies that have provided product liability coverage for you?

____

____

____

25. On a scale of 1 to 7 where "1" is little or no understanding and "7" is great understanding, how well do you understand your insurance policy that provides product liability coverage?

Please circle a number: Little Understanding Great Understanding

1……2……3…….4……5……6……7

26. When learning about product liability insurance where did you find information?

Information Source	Mark box with an "X" if currently use or have used
Insurance Agent	
Social Networks (e.g. Facebook, twitter)	
Other farmers	
Popular press	
Farm Manager or Consultant	
Extension/University sources (e.g., publications, Extension agent)	
Other(s):____________________________________	

D. INFORMATION ABOUT YOUR HOUSEHOLD

27. Check what percentage of your taxable household income was from farming in the last two years?

2011
- ☐ None
- ☐ Less than 25%
- ☐ 25% to 49%
- ☐ 50% to 74%
- ☐ More than 75%

2012
- ☐ None
- ☐ Less than 25%
- ☐ 25% to 49%
- ☐ 50% to 74%
- ☐ More than 75%

28. Check the category that best reflects your taxable household income from both farm and non-farm sources **in 2012**:

- ☐ Under $10,000
- ☐ $10,000 - $14,999
- ☐ $15,000 - $24,999
- ☐ $25,000 - $34,999
- ☐ $35,000 - $49,999
- ☐ $50,000 - $74,999
- ☐ $75,000 - $99,999
- ☐ $100,000 - $150,000
- ☐ more than $150,000

Thank you for your time!

Please place the survey in the enclosed self-addressed postage-paid envelope and return by mail. A summary of the results will be made available at http://vegetables.tennessee.edu/.

VITA

Matthew R. Edwards graduated with a Master of Science in Agricultural Economics in August 2016. While completing his graduate coursework, Matt leveraged his knowledge of geographic information systems and economic valuation techniques through an internship with one of the fastest growing land brokerage companies in the US. Before accepting a graduate research assistantship at the University of Tennessee, Knoxville, he led marketing and expansion efforts of a thriving real estate start-up specializing in lake- and ocean-front vacation rental properties. Prior to earning a B.S. in natural resource and environmental economics from the University of Tennessee in May 2014, he embarked on a month-long journey to Ecuador, South America, where he taught English as a Second Language curriculum to elementary students in Quito, led a hike to the 15,413 ft. summit of Ruku Pichincha Volcano, studied the cultural impacts of early oil exploration in the region, and realized his passion for economic development. Matt's research background is in the application of microeconomic theory to farm business behavior in insurance markets. He has an interest in rural development, land use change, energy and global security, and foreign policy.