Incentives to Supply Enhanced Ecosystem Services from Cropland

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ABSTRACT

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This paper examines the willingness of farmers to participate in hypothetical programs that would pay them to adopt cropping practices that enhance provision of ecosystem services from agriculture. A survey of 3,000 Michigan corn and soybean farmers elicited willingness to adopt four sets of cropping practices that reflected increasing levels of environmental stewardship. Acreage enrollments in the programs were modeled using hurdle models. The acreage that farmers would be willing to enroll depends chiefly on farm size and the perception of environmental improvements from the practices. For farms over 500 acres, the payment offered was also a significant inducement to acreage enrollment in all systems examined. This paper advances the literature on adoption of agro-environmental practices by developing a supply function for crop acreage managed for environmental stewardship. Like prior studies of environmental technology adoption in agriculture, we find that environmental attitudes and affiliations, age, education and current farming practices are influential. But we find that the low cost suppliers of environmental services are the largest farms. Agricultural policies based on payment for environmental services that aim for cost-effective environmental impact will likely achieve most of their impact from larger farms.

Keywords: Willingness to participate, willingness to accept, stated preference, supply response, ecosystem services, payment for environmental services, agricultural policy, agro-environmental policy, environmental policy, corn, soybean

JEL codes: Q18, Q51, Q57

Incentives to Supply Enhanced Ecosystem Services from Cropland

Agriculture is a managed ecosystem. The decisions of its managers drive the mix of ecosystem services that it produces. Farmers play an important role as ecosystem managers in that they balance their decisions regarding land and other agricultural inputs for production and modify their practices to adjust the positive and negative impacts to the environment (Wossink and Swinton, 2007). By their choices of production inputs and management practices, farmers shape their impacts on the environment. Thus, agriculture offers a special opportunity for ecosystem service management because ecosystem services are produced simultaneously with agricultural products.

The policy challenge is to develop incentives for farmers to produce ecosystem services while meeting the demand for food (Hodge, 1991; Hanley and Oglethorpe, 1999). Important policy questions from this growing body of research are:

- What are the incentives that will make the farmers provide ecosystem services?
- Are farmers willing to change their land management practices in exchange for a payment, and if so, how much?
- Which farmers are willing to change their practices and should future policies be targeted toward specific groups of farmers?

The literature concerning what motivates producers to adopt environmentally sound practices has been growing. Empirical studies of conservation farming have found that the most important motives for conservation adoption are “selfish”, financial-economic concerns (Chouinard et al, 2006). Cary and Wikinson (1997) showed that the best way to increase the use of conservation practices is to make them profitable. However non-financial factors also play a role in conservation decisions because producers may gain direct personal satisfaction from the improved environmental quality (Chouinard et al, 2006).

Understanding crop farmers’ willingness to supply nonmarketed ecosystem services calls for understanding the effects of changed cropping systems on both profit and personal satisfaction. The late 1990s saw the emergence of literature on the supply side of environmental improvements from agriculture (Bonnieux and Rainelly, 1995; Bateman et al, 1996; Kazenwadel et al., 1998). These authors focused on the farmers’ willingness to adopt new practices and on the factors influencing their participation decisions. Some studies were based on actual scenarios and some were based on contingent data or hypothetical scenarios. For example, Purvis et al (1989) studied farmers’ willingness to participate in a filter strip program using a contingent valuation survey. The study concluded that farmers’ participation decisions are determined by the yearly payment offered to participants, farmers' perception on environmental change, and their opportunity costs. For example, farmers would be more likely to participate in a filter strip program if the rules allow haying or other economic uses of the enrolled cropland.

This study also uses stated preference survey methods, but it differs from the others in three major respects. First, it takes into account the potential that the attitude and behavior of farmers are influenced not only by farmer and farm characteristics, but also by the characteristics of the required practices or cropping systems. This implies that participation could vary across different types of programs. In order to test this, we evaluated the behavior of the same group of respondents toward four different sets of distinct cropping practices. Second, the paper introduces a subsidy program to make direct payments to the farmers for adopting cropping practices that are known to produce environmental services rather than as a cost sharing program. Finally, this analysis goes beyond participation to address acreage enrollment. In so doing, it becomes possible to estimate farm-level supply functions for land providing specified suites of ecosystem services.

2 Objectives of the Study

The objectives of this paper are: (1) to identify farmer willingness to adopt environmental stewardship practices in exchange for payment (willingness to accept or WTA) to; (2) to investigate the determinants of their willingness to adopt those practices and the relative importance of these factors; and (3) to estimate empirical supply curves for acreage enrollment for hypothetical environmental stewardship programs that correspond to ecosystem service levels that could be produced.

The rest of the paper is organized in two broad sections. The next section introduces the conceptual framework, the research design and the methods of data collection and analysis. The final section summarizes the findings and discusses their policy implications.

3 Conceptual Model: The Supply of Environmental Services by Farm Households

3.1 Multi-attribute Utility Function

A basic premise of the neoclassical economic theory is that rational producers make choices about production inputs and technology (e.g. cropping practices). Following Dupraz et al (2003), farmer behavior is motivated by utility maximization, where utility is increasing in consumption goods and environmental services. Consumption is constrained by net income, which depends on agricultural product revenue minus costs. Thus, farmer behavior can be formalized as follows:

$$\underset{g,es}{Max}\, U(g, es) \qquad (1)$$

$$g \leq \pi(p, es) + NFI \qquad (2)$$

$$es \geq 0 \, . \qquad (3)$$

The parameters of the utility function are household consumption denoted by g and the quantity of environmental service, es, that is co-produced by farming activities. The utility function is assumed to be increasing, concave and differentiable in g and es. The household consumption goods, g cannot exceed the sum of the farm income, $\pi(p, es)$, and exogenous non-farm income, NFI. The profit function, $\pi(p, es)$, is assumed to be convex and is a function of prices of factors and products, p and environmental service, es. The solutions to this utility maximization model are denoted as: g^*, es^* and $g^*, es^*, U^* = U(g^*, es^*)$.

From equations 1 and 2, we see that apart from marketed agricultural products, two kinds of ecosystem services, ES, matter in this model: ES in the utility function and supporting ES in the profit function that substitute for cash inputs in the agricultural production (e.g., soil quality, biological control of crop pests). Thus we expect the demand for these supporting ES to be a derived input demand for ES that depends upon the prices of products and inputs.

3.2 Economic model of Willingness to Accept and Environmental Supply

The microeconomic concept of "willingness to accept" (WTA) is helpful to specify the supply of environmental service. WTA is defined as the minimum amount of income that the farm household would require to supply a given amount of environmental service. WTA is classically formalized by using an expenditure function to provide theoretical structure for welfare estimation. WTA can be represented as the change in expenditure levels of the farm household in response to change in the level of ecosystem services produced, given that their utility is kept the same.

Following Dupraz et al's (2003) derivation for the definition of WTA, we assume that the farmer is invited to increase the environmental service supply, es, by a fixed quantity such that: $\Delta es = es_1 - es_0 > 0$. The expenditure function, $e(p, es, U_0)$, represents the minimum amount of exogenous income which in this case is represented by , $NFI = g - \pi(p, es)$, that is needed to produce a fixed quantity of ecosystem service Δes while maintaining constant utility. Specifically,

$$e(p, es, U_0) = Min[g - \pi(p, es); U(g, es) \geq U_0] \qquad (4)$$

$$WTA = e(p, es_1, U_0) - e(p, es_0, U_0) = e(p, es_1, U_0) - e_0 \qquad (5)$$

where equation 5 expresses the minimum payment that the farmer requires to increase ES production from es_0 to es_1, while maintaining utility level U_0. Letting $g^*(p, es, U_0)$ denote the solution of the cost minimization problem in equation 4, the expression in equation 5 becomes:

$$WTA = [\pi(p, es_0) - \pi(p, es_1)] - [g^*(p, es_0, U_0) - g^*(p, es_1, U_0)] \qquad (6)$$

The first term in brackets in equation (6) is the farm's foregone profit. The second term is the amount that the household is willing to pay for an increase in environmental service. In other words, the willingness to accept equals the foregone profit offset by the monetary value of change in the farmer's utility from producing more ecosystem service. This equation can be restated as:

$$WTA = [\pi(p, es_0) - \pi(p, es_1)] - MVU(p, es_1), \qquad (7)$$

where the function *MVU*(.) represents the monetary value of the utility from switching from the current technology to the alternative technology. This variable shows the utility from producing more ecosystem service expressed in monetary terms via consumption goods.

The changes in expenditure for changes in ecosystem services, $\frac{\partial e^*}{\partial es}$, traces out the farmers supply function for the non-marketed ecosystem service. The area below the supply curve represents the WTA to produce ecosystem services under any given technology.

3.3 The Farmer's Decision Rule

In this study, farmers were not directly asked the minimum amount they would be willing to accept in order to adopt certain cropping systems. Rather they were asked how many acres they would enroll in a program that offers to pay "*s*" dollars per acre and requires them to adopt a set of practices known to produce ecosystem services at some transaction cost involved with participation, denoted *TC*. Thus, the net payment to farmers for enrolling "*a*" acres in the program is *sa - TC*.

The logical condition for farmer enrollment behavior is that for any per acre payment, s, farmers with WTA less than or equal to the net payment from participation are willing to participate in the program (implying $a > 0$), and those with WTA greater than net payment from participation are not willing to participate. Based on the definition of WTA in equation (7), this participation condition can be written:

$$a > 0 \quad iff. \quad [\pi(p, es_0) - \pi(p, es_1) - MVU(p, es_1)] \leq sa - TC \quad . \tag{8}$$

Now, consider a farmer that manages N total acres. Let es_1 correspond to the ecosystem service produced from some portion of land, a out of N acres, that is devoted to an alternative cropping system Q' , and let es_0 correspond to the initial level of ecosystem service produced from devoting all land, N , to the initial cropping system Q^0. Transforming the equation into an acreage based decision model that allows farmers to allocate their land to a hypothetical program that requires them to do a particular cropping system, equation 8 could be rewritten as:

$\pi(N,Q^0) \leq \pi(N-a, p, Q^0) + \pi(a, p, Q') + sa + MVU(Q', Z) - TC(a, Z)$ (9) where π is the profit function; N is total land acreage that the farmer manages; a is the amount of land allocated to production under an alternative technology or cropping system where they are given a subsidy or payment per acre, s . The function, $Q^0 = f(S, es_0, Z)$, is the currently employed production technology, which depends on a combination of systems in the vector *S* which conditions the choice of inputs in the production function, ecosystem services, *es*, and farmer/farm characteristics *Z.* The combination of system, *S*, entails crop choice, rotation tillage, fertility and pest management. *Z* is a vector of parameters that captures characteristics of the farmer that govern his or her preferences for environmental benefits, but also farming experience and willingness to adopt new technologies such as age and education. On the other hand, $Q' = f(S', es_1, Z)$ is an alternative production technology that depends on some other combination of systems thus defining a new set of inputs and new outcome level of ecosystem services; while $TC(a, Z)$ captures various transaction, monitoring and enforcement costs related to participation in the payment for environmental services program that effectively reduce the total size of the subsidy.

The right hand side of equation (9) corresponds to the farmer's profit from re-allocating *a* acres of land to an alternative technology under the subsidy scheme: the first term is the profit generated from $N - a$ acres under the current technology; the second term is the profit generated from a acres under the alternative technology; the third term is the effective (or expected) subsidy payment; and the fourth term is the monetary value of utility from switching to an alternative technology; and the fifth negative term is the transaction costs, TC. The left hand side of equation (9) is simply the farmer's profit under the current technology. Thus, the farmer will have an incentive to allocate land to an alternative land-management system if the combined benefits under the subsidy scheme are valued at least as much as the farmer's current profit.

This decision rule takes into account not only direct costs but also the opportunity cost of deviating from profit maximizing mix of inputs. The farmer's preferences and resource constraints also affect this decision. Thus, participation depends on the cropping systems' relative profitability (Valentin et al., 2004), transaction costs of being involved in the program and general attitudes towards adoption (McCann and Easter, 1999).

4 The Data

4.1 Data Collection

The study asked farmers about their willingness to adopt selected practices from corn, soybean and wheat cropping systems related to ones studied by scientists since 1989 at the long-term ecological research project in agro-ecology at the Kellogg Biological Station (KBS-LTER) near Kalamazoo, Michigan. The payment vehicle drew upon traits of existing U.S. farm programs that pay farmers for providing environmental services. Specifically, the questionnaire offered respondents specified payments if they would participate in a hypothetical farm program that paid them by the acre to adopt specified cropping practices. Farmers who expressed willingness to participate were asked how many acres they would enroll in the program.

The data on farmers' potential supply of enhanced ecosystem services was collected using a mail survey sent to a random sample of 3,000 corn and soybean growers in Michigan in mid-February of 2008. The survey used a four contact version of the tailored design method (Dillman, 1999) consisting of 1) a prenotice letter, 2) a questionnaire and one dollar incentive, 3) a postcard reminder, and 4) a replacement questionnaire. The survey achieved a net response rate of 56.4% after adjustment for refusals, undeliverables and deceased recipients (details in Appendix 8). The survey design and questionnaire development were preceded by a series of farmer focus groups and pre-tests to ensure validity and clarity of the questions as well as an appropriate range of payment offers for those cropping practices. Six farmer focus groups were conducted during February and March of 2007, while in-person questionnaire pre-tests were conducted in January of 2008.

The sample was obtained from the 2007 agricultural census mailing list of the National Agricultural Statistics Service (NASS) office in East Lansing, Michigan. NASS provided the project with a 4-tier, acreage-stratified random sample of 3,000 corn and soybean farmers in Michigan. The four strata represent farmers with 0 to 100, 101 to 500, 501 to 1000 and 1000 and more acres. This method was chosen to allow for comparison across strata to ensure that the farmer population is well represented and that it is linked to the behavioral model on acreage based decision of farmers. In the analyses that follow, weights were used to appropriately correct for the stratification (see Jolejole, 2009, Appendix Table 9).

4.2 The Questionnaire Design

The survey instrument presented farmer respondents with a series of four corn-soybean-based cropping systems. The four systems differ in their degree of cropping practices involved, offering increasing levels of ecosystems services compared to a baseline corn-soybean system. The first, System A, was a corn-soybean crop rotation with chisel plow tillage, pre-sidedress nitrate test in corn, and all agrochemicals broadcast in the field according to Michigan State University recommendations or pesticide label instructions. System B was identical except that a cover crop was added during winter. System C added winter wheat to the crop rotation after soybean, in addition to the winter cover crops after corn and wheat. Finally, System D was identical to System C except that fertilizers and pesticides were applied in bands over the row resulting in a 1/3 reduction in chemical applications. Table 2.1 presents the specific practices for each cropping system.

An orthogonal design framework was constructed to combine the various program attributes and payment levels for the cropping systems into different questionnaire versions (Jolejole 2009, Appendix 5). There were six variables: sequence of cropping systems, payment provider, and the four cropping systems described above, each with 4 levels of prices. The design resulted in 16 versions of the questionnaire, which were randomly assigned within each stratum (details in Jolejole 2009, Appendix 6). The payment levels for each of the cropping systems were set by deriving the bids associated with the 20th, 40th, 60th and 80th percentiles of the distribution of participation predictions that were computed from pilot models that used data from the farmer focus groups held in 2007. Other factors that varied in the framing of the proposed transaction were the payment provider (government or non-government organization) and the sequence of cropping practice questions presented (increasing effort [from system A to D] or decreasing effort [from system D to A]).

Respondents were asked a variety of attitudinal and background questions in order to assess farmer preferences about the environment, the cost of changing practices, and levels of household and farm resources, (Jolejole 2009, Appendices 3 and 7). The stated preference questions were preceded by a full description of how the program works along with instructions on what varied across the questions. The enrollment question was presented as follows: "If a program run by [the government or a non-governmental organization] would pay you $[X] per acre each year for 5 years for using cropping system [Y], how many acres of land would you enroll in this program? (If you would not enroll, please write zero)." Terms in square brackets were varied across questionnaire versions.

5 Methods

5.1 Econometrics of WTA

Farmer respondents were asked to make two decisions with regard to their willingness to accept payments to adopt environmental stewardship cropping systems: (1) Will they participate in the program? (2) If yes, how much of the land area will they devote to environmental stewardship? The econometric hurdle model allows for the possibility that these two decisions are affected by different sets of variables.

The model, originally due to Cragg (1971), has been applied in a variety of areas. Applications include Burton, Dorsett and Young (1996) and Newman (2001), who modeled household expenditure on meat; Jensen and Yen (1996) who modeled U.S. food expenditure outside the home; Yen (1997) who applied the model to alcohol consumption and Jones (1997) who examined U.S. household consumption of cheese. The model has rarely been used in willingness to accept studies. Some exceptions would be Goodwin et al. (1993), Yen et al. (1997) and Reiser and Sheeter (1999).

The hurdle model is a parametric generalization of the tobit model, in which the decision to participate in the program and the level or degree of participation (e.g., acreage enrollment) are determined by two separate processes. This approach allows the two decisions to have different variables or different coefficients with the same variables. This study employs a hurdle model where the probability of participation in the program is estimated as a separate function from the number of acres supplied. The two stages of the hurdle model will be called the participation model and acreage decision model, respectively.

A probit model is used to estimate the initial participation decision. The probit relates choice probability to explanatory factors the program, farm, and farmer characteristics. We let α stand for acres enrolled. The following probit model is used to estimate the probability of participation (i.e., $\alpha>0$):

$$\Pr(\alpha > 0 | x) = \Phi\left(\frac{\beta'_{\rho} x_i}{\sigma}\right) \qquad (10)$$

where $\Phi(.)$ is the standard normal cumulative distribution function, x_i is an $S \times 1$ vector of farm and farmer characteristics for farmer i, and β_{ρ} is the vector of coefficients from the participation model and standard deviation, σ_{ρ} .

The second step of the hurdle is a truncated regression model to account for the acreage enrollment conditional on participation. We first assume a latent acreage variable $\alpha_i *$ that is generated by:

$$\alpha_i * = \beta'_{\alpha} x_i + \varepsilon_{\alpha i} \qquad (11)$$

where x_i is a $S \times 1$ vector of farm and farmer characteristics for farmer i, and β_α is the vector of coefficients for acreage decision and $\varepsilon_{\alpha i}$ are disturbance terms from acreage decision assumed to be independently and normally distributed with mean zero and variance σ_α^ρ.

We observe enrolled acres α_i only if $\alpha_i^* > 0$ so that the expected value of acres is,

$$E(\alpha_i | \alpha_i > 0) = \beta'_\alpha x_i + \sigma\lambda(\gamma) \qquad (12)$$

where

$$\lambda(\gamma) = \frac{\phi(\gamma)}{1 - \Phi(\gamma)} \text{ and } \gamma = \frac{-x\beta_\alpha}{\sigma} \qquad (13)$$

where $\phi(.)$ is the standard normal probability density function and $\Phi(.)$ is the standard normal cumulative distribution function. Equation (13) is the truncated regression for positive values of the continuous decision of how many acres to enroll $(\alpha > 0)$. Note that for observed acres,

$$\alpha_i = \alpha_i^* | \alpha_i^* > 0 \sim \text{Truncated Normal.} \qquad (14)$$

The hurdle model allows the participation decision and acreage enrollment decision to have different coefficients, i.e. coefficients in equations 10 and 12 are different because they arise from separate stochastic models. If they are the same, then a tobit model arises (Lin and Schmidt, 1984). The truncation correction accounts for the fact that only a portion of the distribution is observed (i.e. only the participants), and, therefore, the mean is only calculated based upon what is observed, i.e. participation.

The results from both probit and truncated regressions are important in predicting acreage enrollment, i.e., estimating the supply of land contributing ES. The acreage supply prediction can be computed by multiplying the probability of participation (Equation 10) by the predicted acreage conditional on participation (Equation 12):

$$PREDICTACRES = \Pr(\alpha_i > 0 | x) * E(\alpha_i | \alpha_i > 0) \quad (15)$$

The predicted supply of land contributing ES is traced by systematically increasing the payment variable upward from zero while holding other variables at their mean values.

5.2 Variable Specification and Working Hypotheses

For the participation model, a dichotomous dependent variable for participation indicates whether or not a farmer is willing to accept the offered payment to adopt the environmentally friendly practices (participation=1, nonparticipation=0). For the acreage model, a continuous dependent variable measures the number of acres that the farmer agreed to enroll.

The independent variables are hypothesized to be associated with the adoption of environmentally friendly measures that implicitly links to prior studies on the theoretical derivation of WTA in Equation (11), and the particularity of the farming systems of the study area. The potential explanatory variables that are hypothesized to influence farmers' willingness to adopt to environmental measures are the following:

Payment or subsidy (s). The adoption of changed cropping practices is assumed to cause the farmer to incur additional costs for labor and/or material inputs. As a result, subsidy payments to farmers to adopt stewardship measures are expected to have a positive effect on participation.

Descending sequence. The cropping systems differed in their degree of changes relative to a typical corn-soybean rotation. This variable is a dummy variable that accounts for the manner the cropping systems were presented. (1-descending sequence and 0-ascending sequence) This accounts for the "anchoring effect" of questionnaire versions. Previous studies suggest that it is ideal for this variable to have no effect on participation decision.

Government. This variable is a dummy variable which accounts for the payment mechanism (1-government and 0-non-governmental organization). It might reflect perceived transaction costs involved in participation. One person in the farmer focus groups was adamant that farmers have a higher transaction cost when dealing with the government. It might also measure aversion to government programs or a general political philosophy. Thus, this variable is expected to have a negative effect on participation.

Perceived Environmental Improvement (Monetary Value of Utility from Ecosystem Services, MVU). This variable was measured through a series of 5 point Likert scale questions (1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree and 5 for strongly agree) that measure how much the farmer perceives that the proposed cropping system would outperform their current system in terms of environmental qualities such as soil organic matter, soil conservation, phosphorus surface runoff, nitrate leaching, global warming potential and pesticide risk. The answers for all these environmental services were averaged to derive one variable to measure perceived environmental improvement offered by each cropping system. Lynne et al., (1988) suggest that while economic incentives will increase effort, responsiveness will differ with strength of conservation related attitudes and perceptions. Other empirical studies show that farmers with a generally positive attitude towards new technologies are keen on undertaking and maintaining environmental measures (Shiferaw and Holden, 1998; Abera, 2003). Also, according to a paper by Bonnieux (1998), positive environmental attitude influence adoption of conservation practices. Hence, in this study, a high value of perceived environmental improvement is hypothesized to have a positive effect on participation.

Total Land Area Managed (N) refers to the total area of cropland managed by the farmer at the time of the survey. Empirical studies have found that large farms are more likely to use conservation technology than small farms (Norris and Batie, 1987; Bekele and Drake, 2003). Therefore, it is hypothesized that area of the cropland is positively related with participation.

Current Practices ($Q = f(S, es_0, Z)$). This category consists of several variables that show what the farmers are currently doing on their farms. It includes whether they have wheat in rotation, type of tillage they use, and cover crop use. The proposed new practice may involve costs, but if the farmer is currently doing something similar to the cropping system being offered, the marginal cost of participation will be low and it is expected that they will be more likely to participate.

Biophysical variables (part of Z, farm characteristics) in this study refer to dummy variables for soil texture. Clay soils may be more fertile but less well-drained than the loam soil baseline, whereas sandy soils are less fertile but better drained due to loser particles. Biophysical variables have been found to have a mixed effect on the adoption of environmental measures (Ervin and Ervin, 1982; Norris and Battie, 1987; Pattanayak and Mercer, 1998; Pender and Kerr, 1998). Particularly in this study, adoption of cropping system D which requires less use of chemicals is expected to be positively related to clay soil which is classified to be more fertile than sandy soil and silty soil. Cropping system B, C and D, on the other hand, all of which requires the use of cover crops over winter is expected to be positively related to sandy soil.

Future Price Expectations (p, expected output prices). This category includes expected harvest time prices of corn, soybean and wheat. Wheat-to-corn price ratio and wheat-to-soybean price ratios were also derived. Both are expected to be positively related on cropping systems that require wheat, namely cropping systems C and D and may be negative for cropping systems A and B.

Experiential Variables (Environmental Program Experience; part of Z, farm/farmer characteristics). This consists of several dummy variables that indicate any form of experience with the conservation programs, such as Michigan's Agriculture Environmental Assurance Program (MAEAP) and the federal Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP). Empirical studies have shown that prior membership in conservation programs is positively correlated with conservation practice adoption and effort (Ervin and Ervin, 1982; Norris and Batie, 1987; Sureshwaran et al., 1996; Pattanayak and Mercer, 1998; Bekele and Drake, 2003).

Farmer demographics (Z). This category includes farm and farmer characteristics. Dupraz et al. (2000) found that environmental stewardship programs are more likely to be adopted by farmers with higher education. According to Bonnieux (1998), there is a significant age effect, with younger farmers more likely to adopt conservation practices. Drake (1992) stressed that neighboring farms applying environmental measures, older farmers, higher education and previous participation have positive effects on adoption. Vanslembrouck et al. (2002) found that larger farms, agricultural education, participating neighbors and younger farmers are more likely to adopt.

6 RESULTS AND DISCUSSION

6.1 Descriptive Results

The variables to be included in the regression analysis, their units of measurement and weighted means are presented in Table 2.2. Additional descriptive results are provided in (Appendix 10, Jolejole, 2009). To avoid problems of multicollinearity (Greene, 1997), several variables were dropped from the models, based on F-tests. The final set of variables includes dummies for non-government provider, and descending sequence of cropping system complexity, as well as continuous variables for subsidy payment, perception that the new system being introduced offers more environmental services and total acreage. Other variables included in the analysis are biophysical variables on the most common soil texture for a farm with loam soil as the baseline; current farming practices, including tillage, cover crops and wheat in rotation; expected price of wheat relative to other crops (since wheat is the only crop added in the hypothetical program introduced); experiential variables, and age and education.

Based on the mean values, most of the respondents farm mostly clay soils and practice conservation tillage. Only 9% of the land is planted with wheat and 7% with cover crops. Approximately 15% of the respondents have participated in government programs like EQIP and CRP. Farmers' average age is 54, which is equal to the state average for corn-soy growers (USDA-ERS, 2000).

6.2 The Participation Decision

The results of the probit models for adoption of the four proposed cropping systems are presented in Table 2.3. They include parameter estimates, corresponding standard errors and some regression diagnostics. The pseudo R^2 measure of goodness of fit (McFadden, 1973) ranged from 0.18 to 0.26 for the 4 cropping systems. The p-value associated with each coefficient estimate is the probability that the z test statistic would be observed under the null hypothesis that the particular regression coefficient is zero, given the rest of the predictors in the model. The Wald test was used as an alternative to the likelihood ratio test of whether all the predictor regression coefficients in the model are simultaneously zero. For all the models, the null hypothesis that all the regression coefficients are simultaneously zero was rejected.

The results show that the participation decision in all cropping systems is significantly influenced by the payment, perceived environmental improvement from the system being introduced and the total land acreage operated. Hence, farmers are willing to produce ecosystem services at some subsidy. Perceived environmental improvements from the proposed cropping system and greater total land acreage both contribute to willingness to participate, as expected.

Other factors varied in significance depending on which cropping system is offered. Sandy soil is negative and significant for cropping system D as expected. Moldboard tillage is negative and significant in all cropping systems. The hypothetical program requires chisel plowing. The results suggest that if the farmer is moldboard plowing, he or she is less likely to participate, which likely reflects the fact that switching from one practice to another adds capital costs.

Wheat acres with respect to total land was positive and significant in cropping system C and negative for cropping system A. The ratio of cover cropped land to total land area was positive and significant in cropping system B. These results suggest that if the hypothetical program requires the farmer to do a practice that they already do, they are more likely to participate, which validates the hypothesis we made in the previous section.

The ratio of wheat price to corn price was positive and significant only for cropping system A while wheat price to soybean price was positive and significant for cropping systems B and C. The only result consistent with the previous hypothesis that expected output prices have positive effect on participation would be the positive participation effect on cropping system C.

The USDA Environmental Quality Incentives Program (EQIP) offers financial and technical help to assist farmers to install or implement structural and management practices on eligible agricultural land. Previous experience with EQIP favored participation. This is consistent with the hypothesis that previous experience in similar programs tends to increase participation.

Age was negative and significant for cropping systems A, B and C. This shows that younger farmers are more likely to adopt cropping systems that supply more ecosystem services. The government program provision variable was insignificant for all cropping systems which suggests that farmers do not necessarily view the transaction costs of dealing with the government to be different from those of an unspecified non-governmental organization. The descending sequence variable was negative and significant for cropping systems A and C, which would suggest that farmers are less likely to enroll if the cropping systems are presented in a descending manner. This pattern suggests an anchoring effect.

6.3 Acreage Decision

To capture the second decision faced by the farmer on how many acres to enroll in the program, truncated regression is used to model acres supplied conditional on participation in the program. Respondents who did not participate were not included in this regression. Table 2.4 shows the results. The coefficients in the truncated regressions can be interpreted as the change in underlying latent acreage enrollment for every unit change in the variable, and they have a related effect on the conditional acreage amounts (see equation 12).

For all cropping systems, the amount of acreage enrolled is positive and significantly affected by the total land area managed and relative perception of environmental improvement. The payment offer for adopting the cropping systems is significant and positive for cropping systems A, C and D, but somewhat surprisingly, was not significant for system B.

Other factors varied in significance, depending on which cropping system is offered. Sandy soil is positive and significant for cropping systems B and C as expected. Clay soil, on the other hand exhibits a positive and significant effect on acreage offered in all cropping systems. Clay soil's positive effect on cropping system D is consistent with the hypothesis.

Moldboard tillage reduced acreage enrolled in cropping systems A, C and D, while no-till and conservation tillage undermined acreage committed to cropping system A. The proportion of wheat acres with respect to total land increases acreage enrolled in cropping systems C and D. As hypothesized, the more similar the practices in the cropping system offered to the farmer's current system, the more likely the farmers are to participate which is likely due in part to the cost involved in switching to a different cropping system.

The wheat to corn price ratio has a negative and significant effect on acreage enrolled in cropping systems A and B but a positive effect on cropping system D, which is consistent with the hypothesis. Wheat-to-soybean price ratio showed positive and significant effects on acreage enrollment in all cases. The wheat-to-soybean price effect on cropping systems C and D is consistent with the hypothesis.

MAEAP certification had a surprising negative effect on acreage enrolled, although only for cropping system A. MAEAP offers farmers a certification that their crop management practices are consistent with generally approved agricultural practices in the state. The negative sign means that farmers who are MAEAP certified are less likely to enroll acreage in system A.

Farmer age had a negative and significant effect on acreage enrolled in cropping systems A and C. Education on the other hand, increased acreage enrollment in cropping system D. This shows that younger and more educated farmers tend to enroll more acres. The government program provision variable was negative and significant for cropping systems A and D, which suggests that acreage enrollment decreases when the government handles the program. The sequence variable or the way the cropping systems were presented in the questionnaire was insignificant in all cropping systems.

6.4 Payment Effects By Stratum

Patterns of participation and acreage enrollment in the environmental stewardship cropping systems program varied significantly by farm size stratum. As mentioned in the previous section, the four strata used include stratum 1 representing the 0-100 acre farms; stratum 2 for 101-500 acre farmers, stratum 3 for 501-1000 acre farms and stratum 4 for farms over 1000 acres.

Table 2.5 shows the participation decision with payment effects by stratum. The stratum dummy equals 1 if the farm is in that size stratum and 0 otherwise. The stratum dummies are interacted with the payment or subsidy variable. On the participation decision, strata 4 and 3 exhibited positive and significant payment by stratum interaction effects in all cropping systems. On the other hand, for stratum 2 the interaction is positive and significant only for cropping systems C and D and for stratum 1 it is insignificant in all cropping systems.

Table 2.6 shows the acreage decision with payment effects by stratum. Strata 4 and 3 exhibited positive and significant payment by stratum interaction effects on the acreage enrollment decision for all cropping systems. On the other hand, in Stratum 2 the interaction is not significant in all cases and in stratum 1 it is negative and significant but only for cropping systems A and B.

An unusual result is the negative and significant effect of payments on the acreage decision for stratum 1 in cropping systems A and B. This means that an increase in payment in cropping system A and B will cause farmers to enroll fewer acres of land. This counterintuitive result may be explained by labor time and physical capital barriers for the small farms to be able to meet the required practices. In many instances, adoption of the proposed practice requires new equipment (e.g., band chemical applicator or chisel plow), which could dramatically increase the marginal cost of increasing acreage on small farms. In other cases, the practice may require new knowledge or added work, which may be too demanding for a part-time farm. Either of these effects could mean that the marginal cost of switching from current cropping system to a new one might be very large for the small farms.

Both the probit and truncated regressions indicate that the payment level strongly affects the participation and acreage decisions only for farms over 500 acres, i.e. strata 3 and 4. Smaller farms do not respond to increasing subsidy levels by increasing acreage enrolled. Again, this may be linked to physical capital and time availability barriers to change from their normal operation.

6.5 An Approximation to the Supply Curve

Using the participation and acreage enrollment equations, we adopt the approach of Lee and Helmberger (1985) and McIntosh and Shideed (1989) in predicting program acreage response. The approximated supply curves for acreage enrollment for each cropping system are shown in Figure 2.1. The values used to predict this curve come from the probit and truncated regression results in Tables 2.3 and 2.4 using equation 15. Plotting predicted acreage enrollment for different subsidy levels yields the supply for land for cropping systems that are known to yield ecosystem services.

The first striking pattern in the supply curves is the decline in elasticity with the complexity of the proposed cropping practices. In Figure 2.1, as one moves from Cropping System A (simpler system) to Cropping System D (more complex), the slope of the supply curve becomes steeper, meaning that acreage enrollment becomes less responsive to the increasing payments being offered. This result suggests that more farmers are likely to respond to payment offers for doing cropping system A, which is close to the conventional system and less likely to respond to a payment offer to participate in more complicated cropping system D.

The second striking result is the far greater elasticity of response among larger farms. Figure 2.2, shows the supply curves for acreage enrollment by stratum and cropping system. In all cropping systems, we see that the small farms in stratum 1 have the steepest slope, while the large farms in stratum 4 have the gentlest slope – implying the greatest elasticity of acreage response to payments.

7 Summary and Conclusion

Besides private market goods, agriculture jointly produces a number of public goods that are provided as externalities. This paper examines the incentives of farmers to participate in hypothetical programs to promote cropping systems that would increase production of these nonmarket ecosystem services. Based on a survey of Michigan corn and soybean farmers, we examine stated willingness to adopt sets of cropping practices that embody increasing levels of environmental stewardship. Farmer willingness to adopt these practices is a function of the payment offered, the farmer's perception of environmental improvements from the new cropping system, and total land acreage operated. The amount of acreage farmers would be willing to enroll depends consistently on farm size and the perception of environmental improvements from the practices. Among farms over 500 acres, the payment offered was also a significant inducement to enrolling acreage in these environmentally beneficial cropping programs. We find that under a payment for environmental service program, large farms are the low cost providers of the ecosystem services associated with the cropping systems we studied.

This paper advances the literature on adoption of agro-environmental practices by developing a supply function for crop acreage managed for environmental stewardship. Like prior studies of environmental technology adoption in agriculture, we find that environmental attitudes and affiliations, age, education and current farming practices are influential. But we find that the marginal contribution of environmental services –like most food– is likely to come from the largest farms. These are the ones that exhibit the greatest price elasticity of acreage supply. Notwithstanding the image of the small farmer as environmental steward, future agro-environmental policies that aim for cost-effective environmental impact will likely achieve most of their impact from larger farms.

Figure 2.1 Predicted Farm-level Supply Curves of Acreage Enrolled by Cropping System, 1688 Michigan Corn or Soybean Farms, 2008.

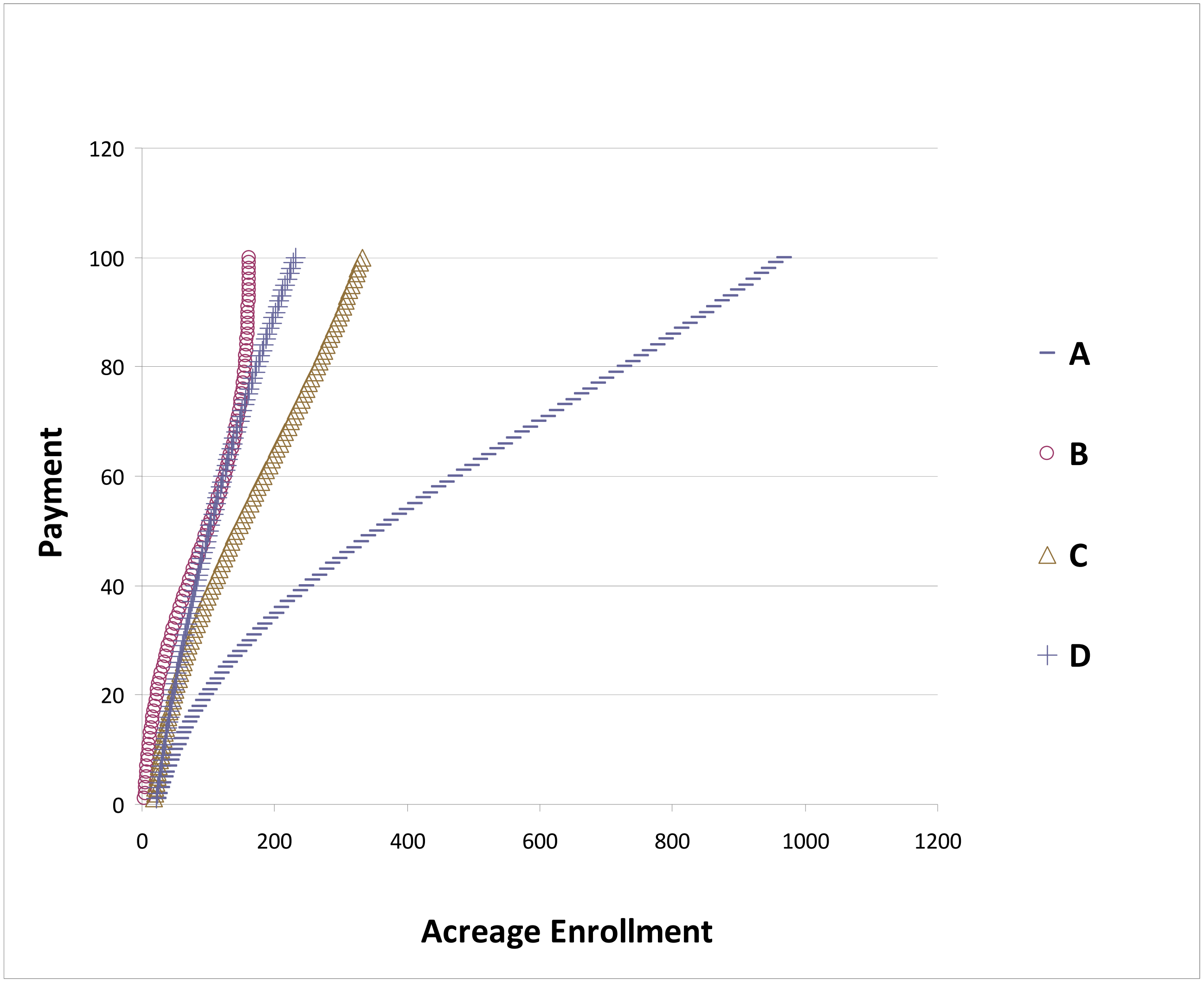

Figure 2.2 Predicted Farm-level Supply Curves of Acreage Enrolled by Farm Size Stratum and by Cropping System, 1688 Michigan Corn or Soybean Farms, 2008.

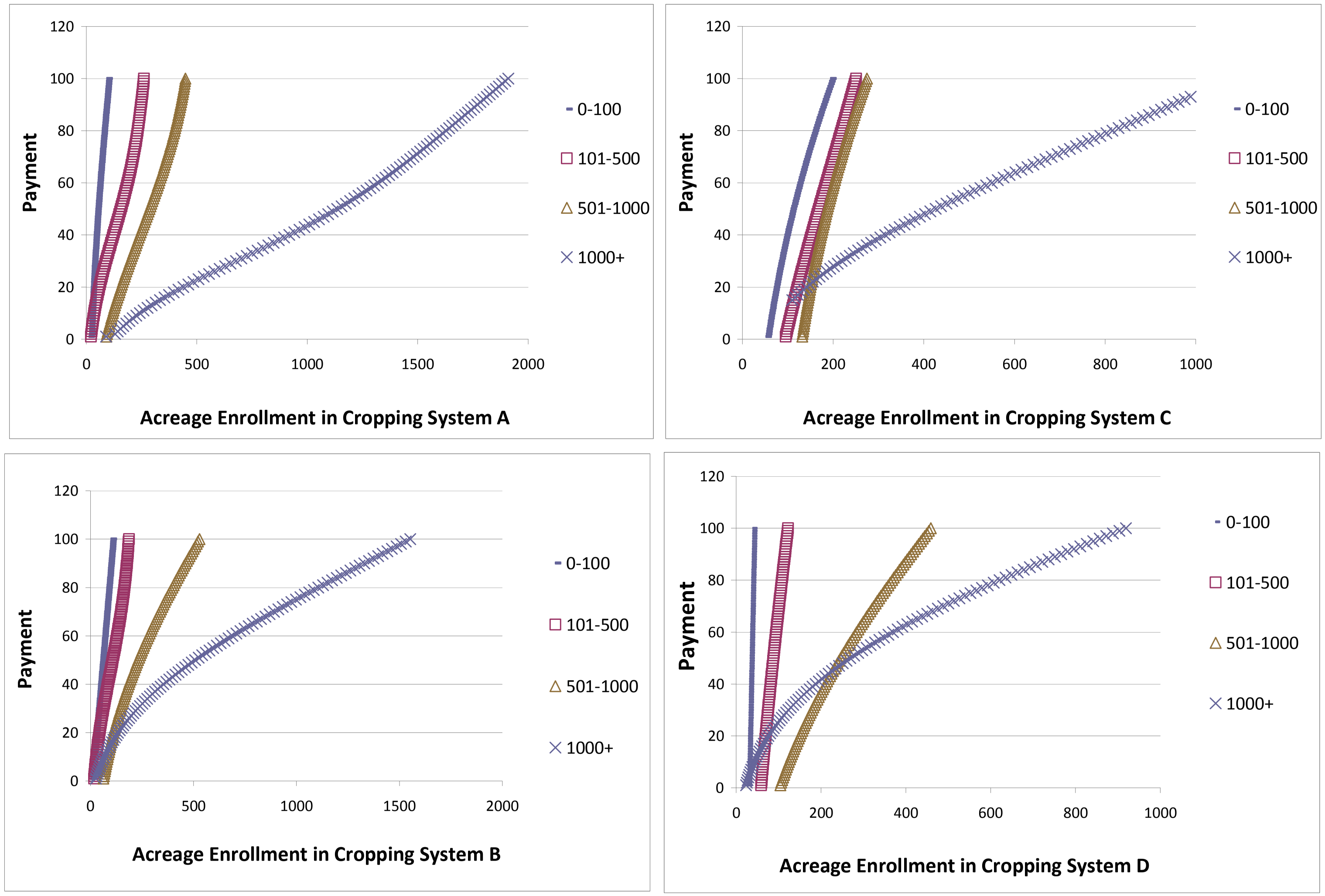

Table 2.1 Specific Practices of the Cropping Systems presented in the Questionnaire

	A	**B**	**C**	**D**
Rotation	Corn-Soybean	Corn-Soybean	Corn-Soybean-Wheat	Corn-Soybean-Wheat
Cover Crops	None	Any type present over winter	Any type present over winter	Any type present over winter
Tillage	Chisel plow with cultivation as needed	Chisel plow with cultivation as needed	Chisel plow with cultivation as needed	Chisel plow with cultivation as needed
Soil Test	Pre-sidedress Nitrate Test (PSNT)	Pre-sidedress Nitrate Test (PSNT)	Pre-sidedress Nitrate Test (PSNT)	Pre-sidedress Nitrate Test (PSNT)
Fertilization	Broadcast fertilizers at full MSU rates and split Nitrogen based on PSNT	Broadcast fertilizers at full MSU rates and split Nitrogen based on PSNT	Broadcast fertilizers at full MSU rates and split Nitrogen based on PSNT	Band apply over row at MSU rates and split Nitrogen based on PSNT
Pesticide Rate	Broadcast pesticides at a label rate	Broadcast pesticides at a label rate	Broadcast pesticides at a label rate	Band apply pesticides over row at a label amount

Source: Crop Management and Environmental Stewardship Survey

Table 2.2 Descriptive Statistics for the Variables used in Regression Analysis, weighted by farm size stratum,1688 Michigan corn or soybean farmers, 2008

Variable	Unit or Type	Mean Value	Standard Error
Version			
Government	Dummy	0.5284	(0.040)
Descending Sequence	Dummy	0.5361	(0.040)
Payment for Cropping System A	Dollars	10.13	(0.400)
Payment for Cropping System B	Dollars	24.12	(0.699)
Payment for Cropping System C	Dollars	35.34	(0.939)
Payment for Cropping System D	Dollars	48.93	(1.27)
Perceived Environmental Performance of Proposed Systems			
System A	Likert 1-5*	3.056	(0.066)
System B	Likert 1-5*	3.317	(0.061)
System C	Likert 1-5*	3.552	(0.059)
System D	Likert 1-5*	3.631	(0.057)
Biophysical Variables			
Sandy Soil	Dummy	0.3194	(0.038)
Silty Soil	Dummy	0.0394	(0.014)
Clay Soil	Dummy	0.5118	(0.040)

ContinuedTable 2.2 Descriptive Statistics for the Variables used in Regression Analysis, weighted by farm size stratum,1688 Michigan corn or soybean farmers, 2008

Variable	Unit or Type	Mean Value	Standard Error
Current Practices			
Moldboard tillage	Ratio	0.1637	(0.024)
No till tillage	Ratio	0.1292	(0.017)
Conservation tillage	Ratio	0.3516	(0.027)
Wheat	Ratio	0.0940	(0.010)
Cover Crops	Ratio	0.0721	(0.017)
Total Land Managed	Acres	453.301	(31.8)
Expected Prices			
Wheat to Corn price ratio	Ratio	1.725	(0.031)
Wheat to Soybean price ratio	Ratio	0.8044	(0.051)
Environmental Program Experience			
MAEAP	Dummy	0.1277	(0.027)
EQIP	Dummy	0.1440	(0.023)
CRP	Dummy	0.2120	(0.302)
CSP	Dummy	0.0667	(0.0154)
Demographics			
Age	Years	54.03	(1.02)
Education Years	Years	13.67	(0.189)

* Mean value constructed from six Likert scale variables for level of agreement that proposed cropping system would improve environmental performance compared to farmer's current system (1=strongly disagree; 5=strongly agree)

Table 2.3 Participation Decision in the Environmental Stewardship Practices (Probit Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Version				
Government	-0.1050	0.0082	0.0527	-0.0779
	(0.20)	*(0.18)*	*(0.20)*	*(0.19)*
Descending Sequence	-0.7069***	-0.3256*	-0.4307*	0.2279
	(0.19)	*(0.19)*	*(0.19)*	*(0.19)*
Payment offer for Proposed System	0.0269*	0.0442***	0.0279***	0.0069*
	(0.02)	*(0.01)*	*(0.01)*	*(0.01)*
Perceived Environmental Performance	0.6899***	0.3989***	0.6226***	0.6263***
	(0.14)	*(0.13)*	*(0.12)*	*(0.14)*
Biophysical Variables				
Sandy Soil	0.3071	-0.3529	0.0169	-0.2289
	(0.33)	*(0.33)*	*(0.33)*	*(0.32)*
Silty Soil	-0.3743	-0.3151	-0.3512	0.2744
	(0.43)	*(0.54)*	*(0.45)*	*(0.48)*
Clay Soil	0.2841	-0.2927	-0.0207	-0.4243
	(0.32)	*(0.31)*	*(0.29)*	*(0.31)*

Continued Table 2.3 Participation Decision in the Environmental Stewardship Practices (Probit Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Current Practices				
Moldboard tillage	-1.0333*	-2.7176***	-1.3516**	-1.0901**
	(0.71)	*(0.75)*	*(0.55)*	*(0.46)*
No till tillage	0.1983	0.8308*	0.4138	0.5059
	(0.51)	*(0.49)*	*(0.52)*	*(0.46)*
Conservation tillage	0.3157	0.4617	-0.0808	0.3436
	(0.39)	*(0.36)*	*(0.35)*	*(0.35)*
Wheat Ratio	-2.0089**	0.7766	1.3810*	0.0775
	(0.96)	*(0.87)*	*(0.81)*	*(0.84)*
Cover Crops Ratio	-0.4831	0.0772*	0.0639	0.0274
	(0.76)	*(0.06)*	*(0.66)*	*(0.49)*
Total Land Managed	0.0002***	0.0001*	0.0001*	0.0001*
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*
Expected Prices				
Wheat price to corn price ratio	1.2601***	0.4510	-0.2531	0.0893
	(0.44)	*(0.31)*	*(0.26)*	*(0.28)*
Wheat price to soy price ratio	-1.2469	0.1602**	0.2171*	0.2421
	(0.85)	*(0.16)*	*(0.13)*	*(0.12)*

Continued Table 2.3 Participation Decision in the Environmental Stewardship Practices (Probit Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	**Crop System A**	**Crop System B**	**Crop System C**	**Crop System D**
Environmental Program Experience				
MAEAP	0.0464	-0.7526	-0.0995	-0.3121
	(0.27)	*(0.25)*	*(0.31)*	*(0.23)*
EQIP	0.5735**	0.4071*	0.7149***	0.9189***
	(0.25)	*(0.21)*	*(0.26)*	*(0.23)*
CRP	0.4579	-0.0978	0.0298	0.1022
	(0.23)	*(0.23)*	*(0.21)*	*(0.22)*
CSP	-0.1695	-0.1966	-0.3629	-0.8617
	(0.30)	*(0.27)*	*(0.31)*	*(0.28)*
Demographics				
Age	-0.0113*	-0.0128*	-0.0108*	-0.0119
	(0.01)	*(0.01)*	*(0.01)*	*(0.01)*
Education Years	0.0410	0.0612	0.0318	0.0328
	(0.05)	*(0.05)*	*(0.04)*	*(0.04)*
Intercept	-5.8257***	-4.4528***	-3.6325***	-3.4891
	(1.19)	*(1.14)*	*(1.21)*	*(1.17)*
N =	642	639	647	656
Log likelihood values	-239.471	-254.851	-321.773	-361.357
Wald chi squared	109.33	110.66	97.95	82.25
Probability chi squared	0.0000	0.0000	0.0000	0.0000
Pseudo R squared	0.2558	0.2544	0.2403	0.1883

Numbers in the parentheses are reported standard errors.

***-significant at 1% level, **-significant at 5% level, *-significant at 10% level

Table 2.4 Acreage Decision in the Environmental Stewardship Practices (Truncated Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Version				
Government	-68.736*	25.022	-13.566	-57.918**
	(38.66)	*(28.07)*	*(25.82)*	*(28.15)*
Descending Sequence	-21.505	-10.489	-34.62	-32.566
	(44.21)	*(27.37)*	*(29.34)*	*(24.38)*
Payment offer for Proposed System	8.5125**	0.1986	1.8316*	3.6052***
	(3.93)	*(1.54)*	*(1.05)*	*(0.91)*
Perceived Environmental Performance	25.803*	19.364*	5.8653*	6.3097*
	(20.31)	*(17.83)*	*(1.78)*	*(2.17)*
Biophysical Variables				
Sandy Soil	-86.157	7.6822*	53.653*	57.063
	(57.39)	*(3.99)*	*(44.62)*	*(60.81)*
Silty Soil	45.092	87.557*	4.5427	36.987
	(167.71)	*(82.45)*	*(68.27)*	*(78.09)*
Clay Soil	48.987*	57.603*	95.520*	94.271*
	(48.94)	*(33.28)*	*(44.54)*	*(57.93)*

Continued Table 2.4 Acreage Decision in the Environmental Stewardship Practices (Truncated Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Current Practices				
Moldboard tillage	-363.63***	-96.744	-96.990*	-75.239*
	(99.85)	*(226.19)*	*(93.60)*	*(69.22)*
No till tillage	-211.01**	-33.193	-23.710	-25.577
	(88.32)	*(72.10)*	*(73.25)*	*(74.71)*
Conservation tillage	-171.32**	2.0510	-66.877	-70.619
	(83.21)	*(65.35)*	*(63.79)*	*(51.97)*
Wheat Ratio	-0.4476	-100.12	119.68*	293.76**
	(128.69)	*(109.64)*	*(103.30)*	*(114.99)*
Cover Crops Ratio	-33.375	-12.094	3.7043	73.600
	(103.38)	*(115.89)*	*(79.08)*	*(61.54)*
Total Land Managed	0.1987***	0.1587***	0.2458***	0.3131***
	(0.03)	*(0.02)*	*(0.03)*	*(0.04)*
Expected Prices				
Wheat price to corn price ratio	-200.99**	-192.04***	-8.7528	50.985*
	(81.54)	*(60.55)*	*(44.44)*	*(33.64)*
Wheat price to soy price ratio	262.17*	383.29***	21.306*	125.46*
	(165.74)	*(133.55)*	*(18.48)*	*(19.44)*

Continued Table 2.4 Acreage Decision in the Environmental Stewardship Practices (Truncated Regression), weighted by stratum, by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Environmental Program Experience				
MAEAP	-156.93**	-134.82	17.242	-68.573
	(62.58)	*(61.08)*	*(46.85)*	*(59.89)*
EQIP	-91.281	10.498	-55.056	8.804
	(61.61)	*(50.68)*	*(44.65)*	*(50.77)*
CRP	-6.9688	38.709	47.623	57.407*
	(41.57)	*(34.73)*	*(36.05)*	*(32.68)*
CSP	94.097	28.544	63.562	38.494
	(68.74)	*(61.74)*	*(64.50)*	*(74.12)*
Demographics				
Age	-4.0063***	-2.2109	-1.9273*	0.6648
	(1.53)	*(1.50)*	*(1.13)*	*(1.36)*
Education Years	6.9434	0.9451	3.6366	9.5676**
	(6.34)	*(6.01)*	*(2.60)*	*(4.58)*
Intercept	604.42***	197.48*	272.05	-13.809
	(226.23)	*(154.42)*	*(184.42)*	*(191.56)*
N=	165	206	285	291
Log pseudolikelihood values	-756.249	-814.661	-1364.405	-1577.31
Wald chi squared	187.15	132.12	158.26	181.43
Probability chi squared	0.0000	0.0000	0.0000	0.0000

Numbers in the parentheses are reported standard errors.

***-significant at 1% level, **-significant at 5% level, *-significant at 10% level

Table 2.5 Participation Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	**Crop System A**	**Crop System B**	**Crop System C**	**Crop System D**
Version				
Government	-0.1396	-0.1251	-0.0976	-0.1285
	(0.19)	*(0.18)*	*(0.18)*	*(0.17)*
Descending Sequence	-0.6057***	-0.2221	-0.4080**	-0.1479
	(0.18)	*(0.18)*	*(0.17)*	*(0.17)*
Payment*Stratum1	-0.0384	0.0042	0.0123	0.0150*
	(0.05)	(0.02)	(0.01)	(0.01)
Payment*Stratum2	-0.0260	0.0197	0.0220**	0.0138**
	(0.02)	(0.01)	(0.01)	(0.01)
Payment*Stratum3	0.0425*	0.0192*	0.0216***	0.0159***
	(0.02)	(0.01)	(0.01)	(0.01)
Payment*Stratum4	0.0650***	0.0153**	0.0244***	0.0245***
	(0.02)	*(0.01)*	*(0.01)*	(0.01)
Perceived Environmental Performance	0.7060***	0.5923***	0.6038***	0.5391***
	(0.13)	*(0.11)*	*(0.11)*	*(0.11)*
Biophysical Variables				
Sandy Soil	-0.3948	-0.0195	0.2406	0.8242***
	(0.31)	*(0.29)*	*(0.32)*	*(0.30)*
Silty Soil	-1.0034	1.0907***	-0.1112	0.0171
	(0.64))	*(0.42)*	*(0.51)*	*(0.45)*
Clay Soil	-0.1730	0.1731	0.2026	0.8232***
	(0.28)	*(0.27)*	*(0.29)*	*(0.27)*

Continued Table 2.5 Participation Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Current Practices				
Moldboard tillage	-1.7883**	-2.8744***	-1.1712	-1.4516**
	(0.85)	*(0.86)*	*(0.74)*	*(0.68)*
No till tillage	-0.7303	-0.2242	-0.0091	0.1390
	(0.48)	*(0.46)*	*(0.47)*	*(0.44)*
Conservation tillage	0.5816	0.0796	0.4370	-0.2311
	(0.48)	*(0.43)*	*(0.37)*	*(0.39)*
Wheat Ratio	-0.0008	0.9967	2.9043***	2.3082***
	(1.10)	*(0.92)*	*(0.90)*	*(0.88)*
Cover Crops Ratio	-0.3791	0.4427*	-0.7560	-0.6135
	(0.64)	*(0.60)*	*(0.54)*	*(0.51)*
Total Land Managed	0.0001*	0.0001**	0.0001*	0.0002*
	(0.00)	*(0.00)*	*(0.00)*	*(0.00)*
Expected Prices				
Wheat price to corn price ratio	0.8253***	0.0705	0.0211	-0.1956
	(0.28)	*(0.30)*	*(0.27)*	*(0.25)*
Wheat price to soy price ratio	-0.0409	-0.3172	-0.2775	-0.0938
	(0.23)	*(0.32)*	*(0.22)*	*(0.18)*

Continued Table 2.5 Participation Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres Dummy	Crop System A	Crop System B	Crop System C	Crop System D
Environmental Program Experience				
MAEAP	-0.0103	-0.3566	-0.2714	0.3167
	(0.27)	*(0.28)*	*(0.26)*	(0.25)
EQIP	0.1049	0.3899*	0.0478	0.1906
	(0.23)	*(0.22)*	*(0.21)*	*(0.21)*
CRP	-0.3098	-0.1441	-0.0930	-0.0765
	(0.21)	*(0.20)*	*(0.20)*	*(0.19)*
CSP	0.3172	-0.0119	0.3270	-0.0660
	(0.31)	*(0.29)*	*(0.31)*	*(0.28)*
Demographics				
Age	-0.0015	-0.0017	-0.0058	-0.0069
	(0.01)	(0.01)	*(0.01)*	*(0.01)*
Education Years	0.0065	0.0086	0.0544	0.0074
	(0.04)	*(0.04)*	*(0.04)*	*(0.04)*
Intercept	-3.9517***	-2.4900**	-3.6200***	-2.7357***
	(1.15)	*(1.07)*	*(1.08)*	*(1.05)*
N =	647	644	652	661
Log likelihood values	-275.338	-339.640	-357.990	-376.662
Wald chi squared	88.41	69.02	84.11	73.27
Probability chi squared	0.000	0.0000	0.0000	0.0000
Pseudo R squared	0.2436	0.1586	0.1999	0.1743

Numbers in the parentheses are reported standard errors.

***-significant at 1% level, **-significant at 5% level, *-significant at 10% level

Table 2.6 Acreage Decision in the Environmental Stewardship Practices with Payment Effects,by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Version				
Government	-210.4295***	-142.2582***	-131.9641**	-108.1522
	(63.09)	*(50.94)*	*(59.14)*	*(66.75)*
Descending Sequence	-267.6296***	-56.8632	-127.7693**	-91.4838
	(63.54)	*(46.79)*	*(52.55)*	*(56.61)*
Payment*Stratum1	-20.3747**	-8.0509*	-0.6727	0.8724
	(10.33)	(4.33)	(2.42)	(3.02)
Payment*Stratum2	-1.6118	-3.0010	-3.1269	2.0692
	(9.54)	(4.01)	(1.92)	(2.47)
Payment*Stratum3	17.7353***	7.0930*	4.9151**	5.2741**
	(6.40)	(3.70)	(2.33)	(2.35)
Payment*Stratum4	32.3271***	9.1168**	4.5525**	9.4482***
	(8.72)	*(4.53)*	*(1.98)*	*(2.44)*
Perceived Environmental Performance	89.8040**	64.2607*	68.2148**	28.6643*
	(58.48)	*(38.37)*	*(44.27)*	*(57.06)*
Biophysical Variables				
Sandy Soil	-35.7487	264.1814***	139.7238*	132.8064
	(147.61)	*(76.95)*	*(82.97)*	*(128.35)*
Silty Soil	-259.1915	194.5706	-36.5880	-52.3980
	(176.17)	*(129.62)*	*(122.50)*	*(148.27)*
Clay Soil	215.7592*	265.8358***	262.7868***	147.8422*
	(129.71)	*(79.34)*	*(78.46)*	*(122.36)*

Continued Table 2.6 Acreage Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Current Practices				
Moldboard tillage	-1223.069***	193.9493	-700.046**	-510.3832
	(348.22)	(527.24)	*(291.33)*	*(343.30)*
No till tillage	-420.8124*	-66.7417	-17.1656	98.5053
	(234.77)	*(186.28)*	*(184.58)*	*(202.38)*
Conservation tillage	-165.1821	49.8453	-89.8856	203.0138*
	(170.19)	*(139.63)*	*(118.90)*	*(113.77)*
Wheat Ratio	-88.4261	35.4787	424.584	515.3281
	(370.66)	*(204.75)*	*(261.70)*	*(326.37)*
Cover Crops Ratio	247.8761	166.8248*	251.5119	314.5113*
	(291.18)	*(120.00)*	*(217.61)*	*(179.68)*
Total Land	0.0484*	0.0798***	0.0767**	0.1684***
	(0.03)	*(0.02)*	*(0.03)*	*(0.06)*
Expected Prices				
Wheat price to corn price ratio	-153.9982	-167.5354***	148.3817**	347.0651***
	(100.64)	*(48.48)*	*(65.63)*	*(94.90)*
Wheat price to soy price ratio	316.262***	597.7731***	376.9607***	444.9625***
	(94.45)	*(45.63)*	*(115.73)*	*(116.76)*

Continued Table 2.6 Acreage Decision in the Environmental Stewardship Practices with Payment Effects, by Farm size stratum and by Cropping Systems, 1688 Michigan corn or soybean farmers, 2008

Dependent Variable: Acres	Crop System A	Crop System B	Crop System C	Crop System D
Environmental Program Experience				
MAEAP	-459.8402***	105.0515	-24.6032	-118.7978
	(130.24)	*(106.39)*	*(67.78)*	*(94.72)*
EQIP	190.9967	-38.8960	-27.5810	73.9469
	(125.29)	*(74.59)*	*(75.10)*	*(92.87)*
CRP	102.8771	34.4273	22.1721	99.4717
	(94.09)	*(67.67)*	*(87.51)*	*(73.68)*
CSP	-174.2692	49.2300	164.5491	-81.2954
	(136.41)	*(75.75)*	*(142.81)*	*(123.41)*
Demographics				
Age	-6.1475**	0.4137	-4.8317**	5.1873
	(2.76)	*(2.91)*	(2.05)	*(3.32)*
Education Years	21.0005*	11.1757	-10.7225	-12.1584
	(11.61)	*(8.68)*	*(12.63)*	*(11.93)*
Intercept	289.74	-679.7855**	163.1455	-180.4859
	(378.46)	*(329.56)*	*(323.11)*	*(399.08)*
N =	168	207	286	292
Log pseudolikelihood values	-1816.731	-2207.975	-3205.686	-3549.953
Wald chi squared	694.31	999.34	307.84	206.38
Probability chi squared	0.0000	0.0000	0.0000	0.0000

Numbers in the parentheses are reported standard errors.

***-significant at 1% level, **-significant at 5% level, *-significant at 10% level

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