Why Farmers Opt Not to Enroll in Payment-for-Environmental-Services Programs

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Abstract:

Payment-for-environmental-services (PES) programs are the focus of increasing attention globally. While existing PES programs can observe who participates and who does not, the reasons for nonparticipation can be opaque. Taking advantage of a unique stated preference data set that includes a follow-up question on conditions for participation, this study differentiates two types of non-participants, those deterred by insufficient payments, and those deterred by fundamental incompatibility with the farm operation. Survey weighted and spatially weighted probit models are applied to examine the determinants of farmers' willingness to enroll in PES programs and their willingness to *consider* enrollment at the same or a high payment. Results suggest the decision to enroll relies more on farm benefit-cost factors, such as program payment, total land area and current farming practice, while the decision to consider enrolling depends more on farm and operator characteristics, such as environmental attitudes, soil traits, current government program enrollment or commitment to organic farming. Both decisions also show evidence of spatial dependence that suggest spill-over effects due to natural resources, interpersonal communication, or other socio-economic factors. These findings elucidate reasons for non-participation in PES programs and provide insights for future program design and targeting.

Keywords: Payment-for-environmental-services, agricultural policy, non-participation, working land, stated preference, spatial probit

JEL codes: Q18, Q51, Q57

1. Introduction

Agriculture is an ecosystem transformed by humans for establishing agricultural production. In addition to supplying food, fiber and fuel (known as provisioning services), agricultural lands can also provide non-marketed environmental services (ES) by farmers' choice of production inputs and management practices, such as soil conservation from reduced tillage, and water quality improvement from less fertilizer application (Wossink and Swinton, 2007). However, many non-marketed ES benefit people beyond the farm gate, so farmers have little incentive to produce those services.

Payment for environmental services (PES) policies are attracting increasing attention globally as a policy innovation that translates external ES values into financial incentives for local providers like farmers (Engel, et al., 2008). PES is formally defined as a voluntary transaction where a well-defined environmental service or a land use likely to secure that service is being 'bought' by a service buyer from a service provider if and only if the service provider secures service provision (Wunder, 2005). In the United States, the focus of federal agricultural PES has recently shifted from land retirement programs, such as the Conservation Reserve Program (CRP), to conservation on working lands--land used primarily for crop production and grazing (Cattaneo, et al., 2005). The 850 million acres of working lands, which is equivalent to 45% of land area of the 48 contiguous U.S. states, have a great potential to provide environmental services. Government spending in the four largest working land programs is projected to grow by 85% between 2002-2007 and 2008-2012 to a total of $11.7 billion[1], largely allocated to the Environmental Quality Incentives Program (EQIP) and Conservation Stewardship

1 Source: Briefing Rooms for Conservation Policy, Economic Research Service (ERS), United States Department of Agriculture (USDA). http://www.ers.usda.gov/Briefing/ConservationPolicy/background.htm

Program (CSP). As the concentration of those programs has evolved from restricting local negative externalities, e.g., soil erosion and nitrate run-off, to providing public goods, like greenhouse gas mitigation and biodiversity, understanding how farmers respond to PES becomes imperative.

Farmers' participation in paid conservation programs has been examined by several studies. Zbinden and Lee (2005) have identified factors influencing farmer' and forest owners' participation in a Costa Rican PES program, in which three fixed levels of payment were provided for reforestation, forest conservation, and sustainable forest management activities respectively. Their results suggested that farm size, household economic factors, and information variables significantly influence the probability of participation in program alternatives. Lambert et al. (2006) have examined farms' adoption of conservation practices/structures and participation in government conservation programs (CRP and EQIP) in the United States based on a USDA Agricultural Resource Management Survey from 2001 to 2003. They found that characteristics of the farm operator and household, in addition to the characteristics of the farm business, were associated with both the likelihood that a farmer will adopt certain conservation-compatible practices and the degree of participation in different types of conservation programs. Two studies also have analyzed farmers' response to hypothetic conservation programs with varied levels of payment. Purvis et al. (1989) studied farmers' willingness to participate in a filter strip program, and showed that their decisions are determined by the yearly payment, perceptions of environmental change, and farm opportunity costs. Jolejole et al. (2009) examined farmers' participation and land acreage enrollment in four environmental stewardship programs. Results suggested farmers' perception of environmental performance, payment offers and total land area are influential.

Those previous studies have commonly examined whether farmers participate in PES programs and the degree of participation measured by enrollment acreage or number of practices. However, underlying reasons for non-participation still remain opaque. For example, some farmers would not enroll in the PES program for inherent reasons regardless of the payment offer, while other non-participants would change their mind with a higher payment. Those types of nonparticipation are difficult to observe by farmers' response at a given payment level. Taking advantage of a unique stated preference data set that includes a follow-up question on conditions for participation, this study separates non-participants who would consider enrolling in the program at a higher payment from those who would not participate even at a high payment level. By diagnosing farmers' reasons for non-participation, this study will inform PES program design about the difference between non-enrollees who are close to enrolling and those who are not.

The rest of the paper is organized as follows: section 2 explains the conceptual formulation of farmer enrollment and consideration decisions; section 3 proposes the study objectives and hypotheses stemming from the conceptual model; section 4 describes the survey data; section 5 introduces the econometric model for enrollment and consideration associated with regression variables; section 6 presents and interprets the regression results; and section 7 summarizes the conclusions and discusses policy implications.

2. Conceptual model

Farmer decisions about participation in PES programs can be viewed as an attempt to maximize their utility subject to resource constraints. Profit maximization is often assumed for farmer's adoption of conservation practices or enrollment in programs. However, this assumption fails to recognize heterogeneity among farmers' preferences (Nowak, 1987) and does not explain why certain profitable practices are not adopted (Neill and Lee, 2001). Therefore, more general studies assume that farmers make the decision from utility maximization rather than profit (Rahm and Huffman, 1984). While the net returns from programs or practices are included in the utility function, other objectives are also considered, such as environmental quality and social benefit. One important class of constraint to adoption of new technology is access to information. Research into the diffusion of new technologies points to the importance of interpersonal communication, including a strong spatial element (Rogers, 1983).

The conceptual framework of this paper is built on a constrained utility maximization model, as shown in Equation (1). The utility of a farmer is assumed to increase in consumption of marketed goods (Z) and nonmarketed environmental services (E). A budget constrains the cost of consumption not to exceed profits from farm production (π) plus nonfarm income (NFI), which includes any incentive payment (P^*) if the farmer enrolls in a PES program. Farm profit (π) is earned from selling agricultural products (Y) at price p_y minus variable cost ($p_x X$) and fixed cost (FC). Output Y is a function of managed inputs X, fixed factors (FC) and unmanaged environmental services (E). The variable cost refers to material and hired labor, while fixed cost depends on family labor (L), capital (K), land acreage (A), biophysical conditions (B) and information (I) available to farmers. Farmers maximize utility by choosing variable seasonal inputs *X* (e.g., fertilizer, seed, hired labor), given fixed capital and family labor. The environmental services (*E*) may affect both outputs and inputs of farm production. Spatial neighborhood effects stemming from interpersonal communication, natural and social conditions (e.g., weather, topography, markets and policies), have possible influence on all factors in the model.

$$\underset{X}{Max}\, U\left(Z, E\right) \tag{1}$$

$$\text{s.t. } Z \leq \pi + NFI\left(P*\right) \tag{2}$$

$$\pi = p_y Y\left(X \mid L, K, B, A, I\right) - p_x X - FC\left(L, K, B, A, I\right) \tag{3}$$

Farmer decisions on participating in PES programs depend on the change of utility after enrollment. Farmers would enroll acreage in a PES program only if the change of utility associated with specific program payment *P** is greater than zero ($\Delta U\ (P^*) > 0$). Among those who opt not to enroll, those who would consider enrolling only if the change of utility associated with their perceived maximum politically feasible payment P^{high} is greater than zero ($\Delta U\ (P^{high}) > 0$).

$$decision = \begin{cases} enroll & \Delta U\left(P^*\right) > 0 \\ not\, enroll & \Delta U\left(P^*\right) \leq 0 \quad \begin{cases} consider & \Delta U\left(P^{high}\right) > 0 \\ not\, consider & \Delta U\left(P^{high}\right) \leq 0 \end{cases} \end{cases}$$

Utility change levels in response to adoption of changed production practices for some payment are unique to individual decision makers in specific settings. Figure 1 illustrates four indicative utility gain (ΔU) curves from a given set of production practices in response to PES payment level (*P*). At the program payment level *P**, the changed utilities are greater than zero for farmer 1 and 2 (ΔU^1 (P*)>0, ΔU^2 (P*)>0), who would choose to enroll. Notably, farmer 1 has positive utility gain from the proposed production practices and would adopt the practices even without payment (ΔU^1 (0)>0). Farmer 2 is willing to adopt the practices with incentive payment P*. In contrast, farmers who choose not to enroll at a given payment may have one of two types of reasons. First, some who face higher costs of adoption may be deterred from enrolling in the program by insufficient payment, but would consider doing so with a higher but still politically feasible payment. The third utility gain curve represents this case (ΔU^3 (P*) <0, ΔU^3 (P^{high}) > 0). On the other hand, fundamental incompatibility may deter some others who have unfavorable physical settings, unacceptably high adjustment cost, negative attitudes toward the proposed practices, or unsuitable management skills. Those farmers are unlikely to consider the program at any likely payment offer, represented by farmer 4 in the figure (P (ΔU^4=0) >> P^{high}). Each farmer perceives a uniquely different change in utility for a given combination of changed production practices. Likewise, each farmer will have a different perception of the maximum feasible payment that determines whether they believe that conditions exist for a higher payment that they might be willing to accept. This study aims to expand our understanding of nonparticipation in PES programs by distinguishing between the motives of those willing to consider enrolling at a higher payment perceived as feasible (case 3 above) and those unwilling to consider enrolling under any payment perceived as feasible (case 4 above).

3. Objectives and hypotheses

Using farmer survey data from Michigan, this study aims to: 1) differentiate non-participants into “consider” and “not consider” groups, and investigate determinants of these two types of non-enrollment; 2) examine determinants of a conventional model that differentiates “enroll” from “not enroll” groups; 3) compare similarities and differences of the two decisions and use farmers’ qualitative statements to support econometric results; and 4) analyze neighborhood spatial effects on farmer’s enrollment and consideration decisions using on ZIP code level data.

Two hypotheses are to be tested in this study:

1) Same underlying factors determine the enrollment decision and consideration decision;

2) No neighborhood effects exist in the enrollment and consideration decisions.

4. Data

Data for this study come from a 2008 mail survey of Michigan corn and soybean farmers that yielded 1688 responses (56% response rate). All farms in the sample were randomly drawn from four strata with 0 to 100, 101 to 500, 501 to 1000 and 1000 and more acres respectively to ensure that the farmer population is well represented. Each respondent was presented with four hypothetical cropping systems that differed in their management complexity and provided different levels of soil conservation, water quality and greenhouse gas mitigation services (Table 1). System A, the base system, was a corn-soybean rotation with chisel-tillage and university fertilizer recommendations based on soil testing. System B added a winter cover crop, system C added wheat to the crop rotation, and system D added a requirement to band fertilizer application over the crop row and reduce rates by one third below university recommendations. For each cropping system, respondents were offered a specific payment if they would adopt the system for a period of five years, and they were asked how many acres they would enroll in such a program. Farmers who would "enroll" or "not enroll" were distinguished by this question. Respondents who chose not to enroll any land were asked whether they would consider enrolling in that system if the payment were higher. Farmers who "consider but not enroll" in the program and those who would "not consider" were further differentiated. See Figure 2 for differentiation of those groups, and Figure 3 for the number of farms falling into different groups for each cropping system proposed. Average payment levels were higher for systems with more management complexity (Figure 3 does not take the differing payment levels into account). Respondents received different versions of the questionnaire with experimentally designed variation in the payment levels and sequencing. Some respondents faced a sequence of increasing complexity of systems with nondecreasing payment offers, while others faced the opposite sequence. In the survey, farmers were invited to write down the reasons for their choices. Detailed information about data collection and questionnaire design can be found in Jolejole (2009).

5. Econometric model and variables

To model the participation in PES programs, several functional forms have been used in the literature. Since the basic participation decision is a dichotomous choice, binary response models such as probit and logit have often been used (Zbinden and Lee, 2005, Lambert et al., 2006, Jolejole et al., 2009). Multinomial logit was also applied for best choice among program alternatives (Zbinden and Lee, 2005, Lambert et al., 2006). The degree of participation such as land enrollment proportion (Purvis et al., 1989), enrollment acreage (Jolejole et al., 2009) and number of practice (Lambert et al., 2006), were also analyzed using tobit, truncated regression and negative binominal models respectively.

Farmers' participation responses at the two decision levels are "yes" or "no" choices. Thus, a probit binary response model is used to estimate factors affecting enrollment choice (enrollment model) and two types of non-enrollment choice (consideration model). The probit model in Equation (4)-(6) builds on the random utility framework (McFadden, 1974), where y is the binary dependent variable indicating farmers' enrollment or consideration in the two models respectively. y* is a latent variable measuring farmers' utility from their choice. X is a vector of explanatory variables influencing the utility. The error term ε is assumed to have a normal distribution with zero mean and variance σ^2. As farms are divided into four strata with different percentages being sampled, the estimates for both probit models are weighted by the probability that each observation is randomly drawn from its stratum (Table 2).

$$y = \begin{cases} 1 & if \quad y^* > 0 \\ 0 & if \quad y^* \leq 0 \end{cases} \tag{4}$$

$$y^* = X\beta + \varepsilon \quad \varepsilon \sim N(0, \sigma^2) \tag{5}$$

$$\Pr\left(y^* > 0 \mid X\right) = \Phi\left(\frac{X\beta}{\sigma}\right) \tag{6}$$

We also test the spatial dependence among those responses, which may come from interpersonal communication, natural and social factors. Spatial dependence is formally defined as "the existence of a functional relationship between what happens at one point in space and what happens elsewhere” (Anselin, 1988). The spatial weighting matrix (*W*) is used to model spatial relationships based on the ZIP code level spatial data (Figure 4). Each element of the weighting matrix (w_{ij}) measures the inverse distance between the centroids of ZIP code areas *i* and *j*. The basic assumption is that farms located in the same ZIP code area are highly affected by unobserved neighborhood natural and socio-economic factors, while farms in ZIP code areas within 25 kilometers are also related at levels that decay with distance.

In expanding the binary choice decision to accommodate spatial dependence, the spatial probit incorporates spatial structure into the specification of y* as in Equation (7)-(9) (Franzese Jr and Hays, 2008):

$$y = \begin{cases} 1 & if \quad y^* > 0 \\ 0 & if \quad y^* \leq 0 \end{cases} \tag{7}$$

$$y^* = \left(I - \rho W\right)^{-1} X\beta + \varepsilon \tag{8}$$

$$\varepsilon \sim N(0, \sigma^2 V) \qquad V = diag(v_1, v_2, ..., v_n) \tag{9}$$

This model is similar to the non-spatial probit model in Equation (4)-(6) except for building in spatial effect and heteroskedasticity in the error terms. ρ denotes the spatial autoregressive parameter that measures the spatial lag of the latent variable estimate compared with a non-spatial model. *I* is the unit diagonal identity matrix. *W* denotes the spatial weighting matrix constructed on inverse distance between ZIP codes[2]. As heteroskedasticity (represented by V) is often present in spatial models of probit

[2] Centroid for each zip code area is firstly constructed. Farms in a zip code are assumed to be correlated with farms in nearby zip code areas within a radius of 25000 meters from centroid. Different farms in each zip code are assigned a higher weight, the inverse of 6500 meters (the radius of median ZIP code area).

estimation, a Bayesian spatial probit estimation with Gibbs sampler is used to analyze the spatial effects (LeSage, 1999)[3].

To test whether the same set of determinants underpin both enrollment decisions and consideration decisions, two weighted probit models are estimated. The dependent variable for *enrollment* model is farmers' choice of enrollment or not, whereas the dependent variable for *consideration model* is farmers' choice to consider but not enroll or not consider. The dependent variable for *spatial probit model* is binary choice of enrollment or consideration respectively. See Table 3 for descriptive statistics of dependent variables.

Five broad categories of explanatory variables linked to the conceptual model are defined as follows (Table 4). First, *questionnaire version* category, corresponding to program payment *P**, includes the level of payment provided with each cropping system, the sequence of payment level and whether the payment is provided by government. The payment is the direct benefit or cost saving from enrolling in the program. The adoption of changed cropping practices is assumed to cause farmers to incur additional direct costs (e.g., for labor and/or material inputs) and opportunity costs (e.g., for growing a less profitable crop). Based on results from farmer focus groups in 2007, the payment offer ranges for the four cropping systems were: A: $4 to $17; B: $10 to $36; C: $15 to $55; and D: $20 to $75. The payment offer is assumed to have more effect for enrollment decision than consideration decision. The descending sequence variable is a dummy variable denotes increasing/decreasing sequence of cropping system complexity and

3 Since the Bayesian spatial probit estimation does not apply to a weighted model, spatial effect is only examined in unweighted stratum-level models. Due to limited data in each stratum, fewer variables are used as regressors.

payment level. Previous studies suggest that it is ideal for this sequencing variable to have no effect on participation decision.

Second, the *perception and attributes* category of variables, corresponding to environmental services *E*, depicts farmers' perception of ES benefit from certain cropping systems and their attitudes on whether nature provides services that could benefit their production. These variables are 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). Past studies have shown that farmers' positive perception (D'Emden, et al., 2008, Gould, et al., 1989, Sidibe, 2005, Traore, et al., 1998, Wei, et al., 2009) and attitudes (Lynne, et al., 1988, Sheikh, et al., 2003) tended to promote enrollment in conservation programs.

The third category describes the *biophysical attributes* of farms corresponding to biophysical conditions *B*, which includes farm size and soil types. Farm size is expected to have positive effect since larger farms have a higher capacity to invest and to withstand risks from changed practices (Knowler and Bradshaw, 2007, Prokopy, et al., 2008). Soil type refers 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 looser particles. Soil attributes exhibited mixed effect in different studies depending on the specific practices. In this study, enrollment in a system with 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, while the use of cover crops over winter is expected to be positively related to sandy soil (Jolejole, et al., 2009).

The fourth category measures *farm management attributes,* corresponding to variable input *X*, labor *L* and capital *K*. The current practices of tillage, wheat acreage, cover crops, irrigation, organic crops, pre-sidedress nitrate test (PSNT), fertilizer and pesticides[4] are expected to have a positive effect on participation if they are similar to the proposed cropping system. Irrigation of farmland has mixed influence on adoption of new practices. It facilitates the adoption of PSNT[5], but prevents reduced tillage and crop rotation[6] (Bosch, et al., 1995, Wu and Babcock, 1998). These results depend on the payoff of irrigation associated with different practices. Various studies suggested that when farmers were involved in a conservation program they were more likely to participate since they had more information on those practices and shared costs (Bosch, et al., 1995, Ervin and Ervin, 1982, Wei, et al., 2009, Wu and Babcock, 1998).

The fifth category is *operator attributes,* including age and level of formal education of farm operators, which may influence farmers' information *I* and choice of practice *X, L and K*. Most studies found education can improve farmers' acceptance of new practice, and hence increase the probability of participation (Prokopy, et al., 2008). Studies also found that older farmers were reluctant to change their current practices (Bosch, et al., 1995, Rahm and Huffman, 1984, Wu and Babcock, 1998).

6. Results

Our results reject the hypothesis that the enrollment decision and consideration decision are determined by same factors. The enrollment decision is found to rely more on program benefit-cost criteria, while the consideration decision depends more on farm

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[4] Reduced fertilizer and pesticides are dummy variables with one indicating currently band apply fertilizer/pesticide to 2/3 of full field rate.
[5] Irrigated farms tend to use more fertilizer, while the PSNT helps them to reasonably reduce the application.
[6] Crop residues resulting from reduced tillage interfere with irrigation; crop rotation reduces the payoff from irrigation by growing less water-intensive but high-valuable crops.

and operator characteristics. Table 5 and Table 6 show the coefficient estimates from weighted probit regressions. Farmers' comments on participation choices are also incorporated to inform the interpretation of regression results.

Two common factors underpin both consideration and enrollment decisions. First, the perceived environmental performance of each system significantly contributes to both enrollment and willingness to consider each of the four cropping systems. This finding is consistent with previous studies, as the perceived ES benefits both individual farmers and the society. Feedback from surveyed farmers about reasons to enroll or not enroll in the program reveal more care about individual benefits, such as soil fertility, than social benefits like global warming mitigation[7].

Second, the similarity of current farming management and technologies to the proposed cropping system also increases willingness to participate and consider the program due to lower risk and less extra cost. Willingness to add wheat to the corn-soybean crop rotation is a case in point. In the words of respondent R2525, who enrolled, "We already use a corn soy wheat rotation like this." In the models for system C and D that add wheat into the crop rotation, a higher proportion of land previously in wheat significantly increases the probability of both consideration and enrollment. The influence of the wheat area proportion on enrollment is significant at 1% level, while it is only significant in the consideration model at 10% level. From farmers' comments, we learn that those who decline to enroll in the program for systems C and D but would consider doing so for a higher payment plant less wheat acreage or find wheat to be less

[7] "Better crop yield and conservation farming, not waste of fertilizer and pesticides" (R0401, enroll)
"Increase in organic matter and soil conservation" (R1732, enroll)
"Global warming is a crock but carbon is good for yields" (R608, enroll)
"Technology gains for products and environment" (R587, consider but not enroll)
"[This system] would be going backwards on soil conservation" (R2725, not consider)

profitable[8]. Those who will not even consider enrolling are often restricted by incompatibility with other farm operations[9].

Five benefit-cost characteristics distinguish respondents who chose to enroll in the program compared with those who chose not to enroll. First and foremost, the per-acre payment offer for each system significantly encourages enrollment (Table 5). The payment variable has a positive effect for all systems in the enrollment model, whereas it negatively influences the consideration decision for system B and C (Table 6). Some farmers who choose to enroll or consider the programs are attracted by the program payment offer or a possible higher payment, while farmers who would not even consider enrolling concern more about other barriers that can only be overcome by infeasible program payment[10].

Second, the decreasing sequence of cropping system complexity and associated payment levels reduces enrollment in all but the most complex system. This unexpected effect suggests psychological anchoring by respondents who become disinclined to enroll for lower payments, despite the simpler systems. By contrast, decreasing cropping system complexity promotes willingness to consider the program in the two most complex systems.

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[8] "Wheat rotation is too high of a percentage for me" (R2513, consider but not enroll)
"Wheat is less profitable, don't want to cultivate" (R206, consider but not enroll)

[9] "We do not have time to harvest wheat" (R604, not consider)
"We don't grow wheat because we feed beef steers and need corn for feed" (R1034, not consider)

[10] "Good stewardship of land. The 75/acre would help with the cost of soil nitrate testing along with establishing cover crops." (R549, enroll)
"It follows my system fairly closely 36 is an incentive if the system works." (R689, enroll)
"Not enough money to be in a fixed program. I like to be able to change." (R1504, consider but not enroll)
"$39 doesn't cover cost of seed and planting cover crop." (R501, consider but not enroll)
"Yield reduction of spring tillage on heavy clay soils would require a 350 per acre payment." (R1014, consider but not enroll)

Third, farms with greater total cropland area are more likely to enroll in the program. Large farms have the flexibility to enroll without committing all of their available land and can spread any fixed costs of adoption over more output. [11] Some smaller operators weighed the benefits of the per-acre payment against the fixed transaction costs of enrolling. Said respondent R274, who has 320 acres and did not enroll but would consider it at a higher payment, “not enough acres to put up with the paper work.” For the smallest farms, the cost of changing equipment often outweighed the total value of program benefits. A case in point was respondent R0011, who has 8 acres and would not consider enrolling, whose terse comment stated, “cost of equipment on very limited acreage.”

Fourth, the percentage of moldboard-tilled land has a negative effect on enrollment but no effect on consideration decision in any system, presumably due to the fixed cost of converting to a chisel plow, which is required by all four systems. Farmers may consider the program if that cost can be compensated by a higher payment, otherwise they would not consider[12].

Last, farmers who have already band applied fertilizer were more inclined to enroll in system D, which requires band fertilizer at 2/3 of university recommendation rate. Farmers who choose not to enroll are commonly restricted by equipment availability or undesired effects from banding[13]. Respondents who band apply fertilizer were more likely to enroll in system D due to consistency with current practice. However, results

[11] “Steady income for 1/2 my acres could still continue no till practices on other 1/2” (R2947, enroll, 929 acres)

[12] “Just because we still chisel some acres” (R2629, enroll)
“Higher cost and investment in machinery” (R164, consider but not enroll)
“I have the best crops with moldboard plow.” (R9, not consider)

[13] “We don’t have equipment for band apply fertilizer” (R95, not consider in D)
“We got away from banding fertilizer years ago. It makes the corn plant lazy and without root system it tends to suffer in drought conditions.” (R993, not consider in D)

also suggest that for systems A, B, and C some of those farmers would consider converting back from banding to broadcasting fertilizer, if a higher payment were provided[14].

Among respondents who opted not to enroll in the program, those who would consider enrolling are motivated by attitudinal, demographic and resource quality factors.

Farmers who believe their production can benefit from nature are more likely to consider enrolling in the program. Their attitudes would further enhance participation when combined with perceived positive environmental services. This is observed from farmers' Likert ratio answers related to the links between agriculture and the environment.

Younger farmers and those with more education are also more apt to consider the program. Presumably young farmers have enough time to try new practices and would be more open to new ideas[15].

In terms of biophysical resources, respondents whose farms have less fertile sandy soils or poorly drained clay soil are less likely to consider system A that requires corn-soybean rotation and chisel plow tillage[16].

Respondents with a high proportion of land committed to organic farming are also less likely to consider any of the four systems. Changing away from organic production

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[14] "I already band all my fertilizer." (R608, enroll in D)
"We already band fertilizer and use less than MSU recommendations. More fuel, more labor, less conservation." (R2958, consider but not enroll in B)
"I like applying stacked bands of fertilizer (R2363, consider but not enroll in C)

[15] "I would enroll if I were younger. I am too old to enroll in 5-year program." (R1209, not consider)
"I don't have the machinery. I'm too old to purchase new." (R627, not consider)

[16] "Soil too sandy for soybean rotation" (R1157, not consider)
"My soil is sand and rolling. I only plant enough corn to feed the cattle and enough soybeans to pay input costs and the rest is alfalfa." (R1237, not consider)
"I don't cultivate anymore and my ground is heavy clay and it needs to be moldboard plowed." (R2379, not consider)

would impose a substantial adjustment cost and would also likely run counter to organic farmers' environmental attitudes[17].

Moreover, farmers who have participated in CRP, which provides both financial and technical assistance for adopting a wide range of conservation practices on both retired land and working land, showed higher interests in the programs proposed.

The second hypothesis that no neighborhood effects influence farmers' participation decisions is also rejected. The spatial probit estimation suggests that positive neighborhood effects influence both participation and consideration decisions among farms. However, correcting for spatial structure only leads to a minor change in the magnitudes of coefficient estimates. See Table 7 for spatial versus non-spatial comparison of coefficients and significance for enrollment model of system D. Significant spatial autoregressive parameter ρ in all four systems for both consideration and enrollment decisions can be seen in Table 8. Although spatial effects are generally unobservable by normal explanatory variables, farmers directly expressed some local or regional influences[18].

7. Conclusion

In sum, this paper complements the literature on farmer participation in payment-for-environmental-services programs by distinguishing two variants of program non-

[17] "Farm in organic program" (R2019, not consider)
"Because I would like to go to organic I don't agree with fertilizer and pesticide and spray." (R2512, not consider)

[18] "In my location in northern Michigan, corn has not been a viable cash crop even high moisture corn for local dairy farms is only profitable for soil building values" (R840, not enroll)
"Wheat delivery and acceptance at local elevations would need to get significantly more farmer friendly" (R1117, not enroll)
"Wheat does not grow well in Kalamazoo county" (R2242, not enroll)
"Compliance must be 100% through your community or noncompliance farmers would have a tremendous advantage when it comes to rent prices" (R1818, consider but not enroll)

participation. It separates the enrollment decision from a decision among non-enrollees about whether they would be willing to consider enrolling at a higher payment. The decision to enroll relies more on farm benefit-cost factors, such as program payment, total land area and current farming practice. By contrast, the decision to consider enrolling depends more on farm and operator characteristics, such as environmental attitudes, soil traits, current government program enrollment or commitment to organic farming. Both decisions show evidence of spatial dependence that suggest spill-over effects due to natural resources, interpersonal communication, or other socio-economic factors.

The characteristics that differentiate the consideration decision from enrollment decision can provide better insights for PES program targeting and design. As revealed by the consideration model, PES programs that propose farming practices that significantly conflict with farm operations or farmer's characteristics are unlikely to be adopted even if a large payment were offered. Thus, PES programs that aim to be effectively adopted may directly target young, well educated farmers who are favorably disposed toward environmental stewardship but not committed to practices that are inconsistent with those proposed.

The enrollment model also suggests ways to expand participation rates by program design. Farm cropping systems vary considerably, including crop rotation, tillage, fertilizer and pesticide application. The divergence in any aspects between current cropping system and the proposed one may pose benefit-cost barriers to enrollment in PES programs. Thus, a flexible program that is separable in practices associated with different payment levels may facilitate a higher participation rate. A flexible program will also be more adaptable to heterogeneous land and management skills. Finally, research and outreach that build farmer understanding of environmental services from agriculture also contribute to the appeal of agricultural PES programs.

Figures and Tables

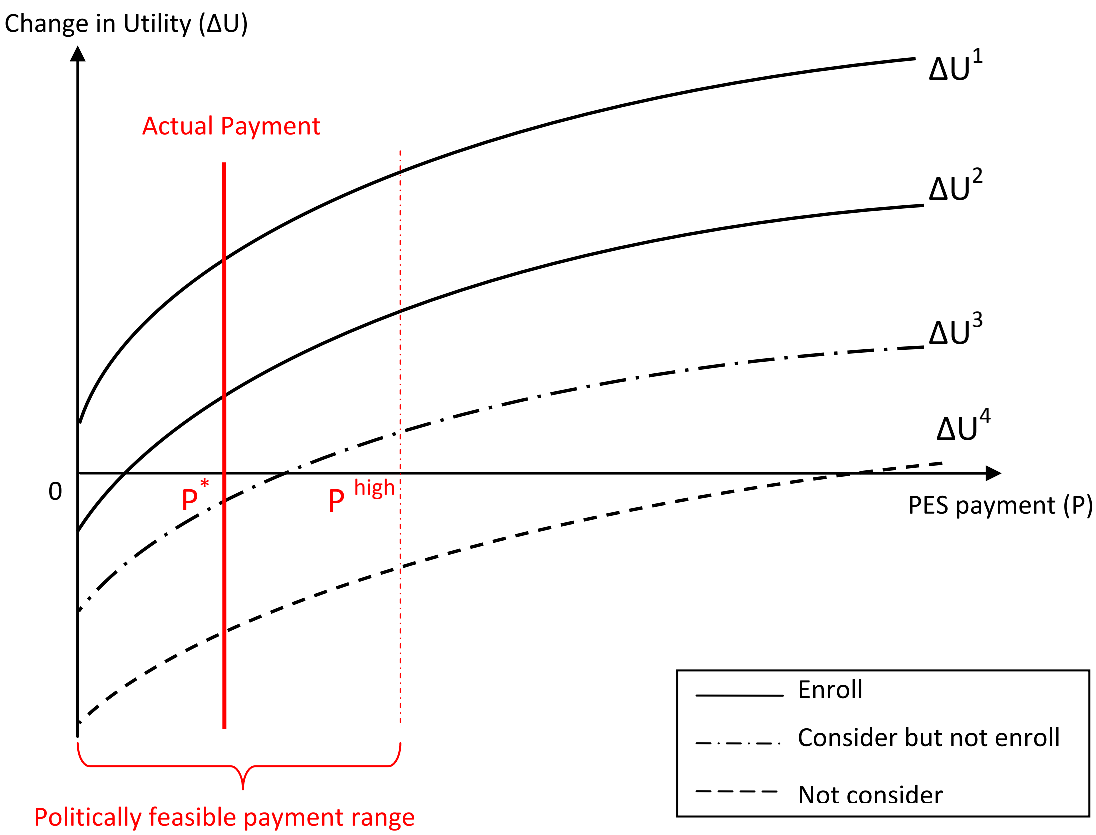

Figure 1 Illustration of 4 farmers' change in utility from adopting specified production practices as a function of the associated PES payment.

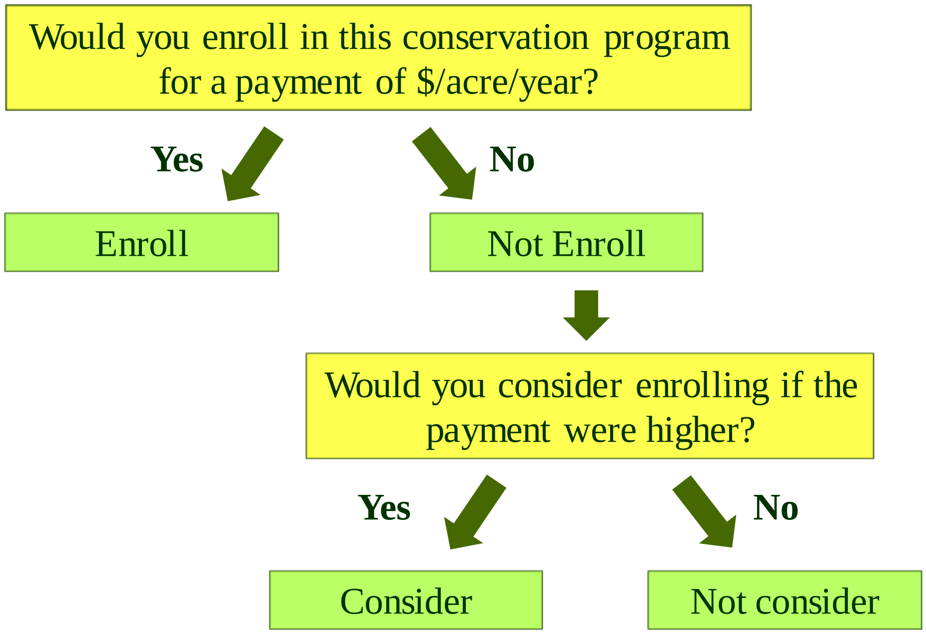

Figure 2 Farmers' two-level participation decision for PES programs.

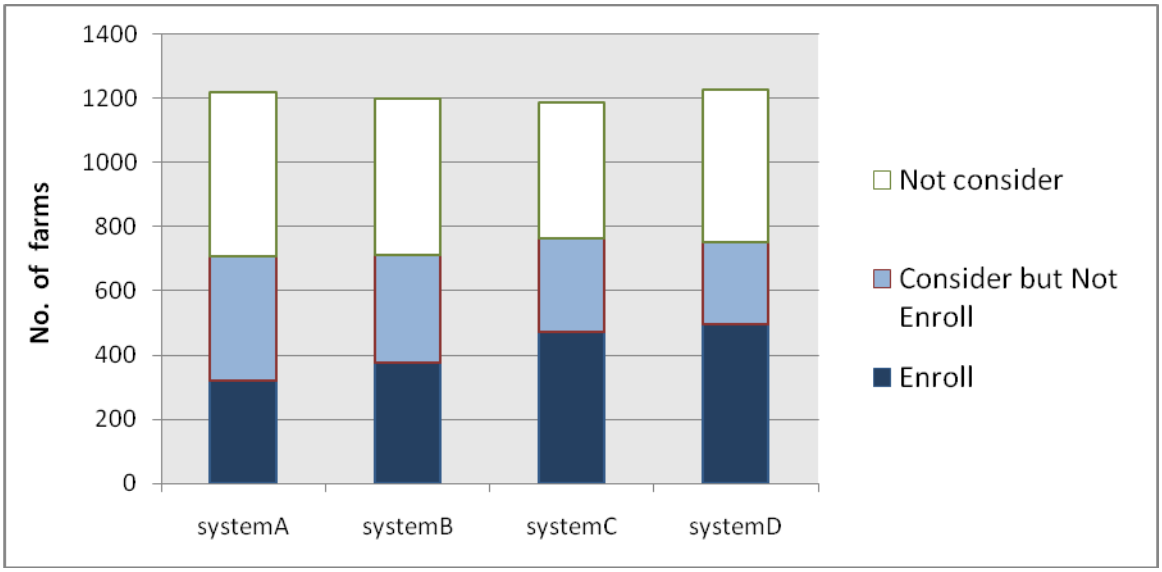

Figure 3 Number of farms participated in four cropping systems, 1688 Michigan corn and soybean farms, 2008

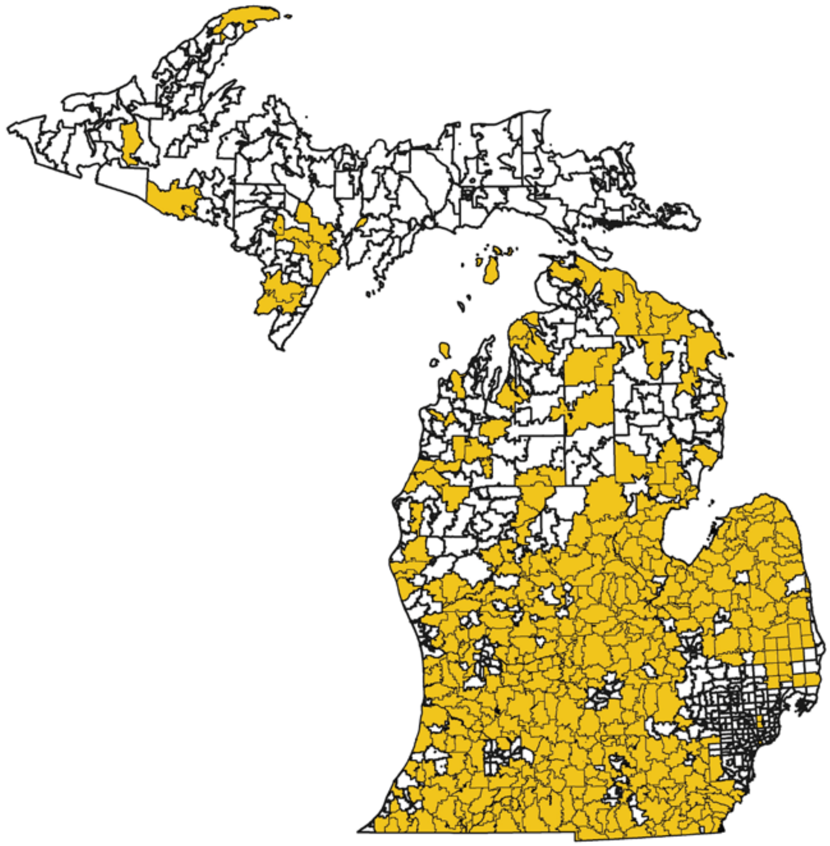

Figure 4 ZIP code areas of respondent farms.

Table 1 Four cropping systems

	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

Table 2 Sample weights for probit models

Strata	Acres	No. of farmers (n_i)	No. of sampled farmers (s_i)	True shares (n_i/N)	Sample shares (s_i/S)
1	0-100	9849	301	0.5585	0.1003
2	101-500	5545	1050	0.3144	0.35
3	501-1000	1361	770	0.0772	0.2567
4	1000+	879	879	0.0498	0.293
Total		N=17634	S=3000		

Table 3 Descriptive statistics of dependent variables

Dependent Variable	system	unit	Obs	Mean	Std. Dev.	Min	Max
Probit model: enrollment							
Enroll VS Not enroll	A	binary	1265	0.253	0.435	0	1
Enroll VS Not enroll	B	binary	1238	0.305	0.460	0	1
Enroll VS Not enroll	C	binary	1223	0.387	0.487	0	1
Enroll VS Not enroll	D	binary	1274	0.389	0.488	0	1
Probit model: consideration							
Consider but not enroll VS Not consider	A	binary	826	0.409	0.492	0	1
Consider but not enroll VS Not consider	B	binary	748	0.388	0.488	0	1
Consider but not enroll VS Not consider	C	binary	639	0.382	0.486	0	1
Consider but not enroll VS Not consider	D	binary	653	0.314	0.464	0	1

* Note that the average prices in the experimental design increase as one moves from system A to system D.

Table 4 Descriptive statistics of independent variables

Independent Variables	Units	Obs	Mean	Std. Dev.	Min	Max
Questionnaire Version						
Government	binary	1796	0.497	0.500	0	1
Descending sequence	binary	1796	0.503	0.500	0	1
Payment offer (system A)	dollars	1796	10.214	4.775	4	17
Payment offer (system B)	dollars	1796	23.243	9.045	10	36
Payment offer (system C)	dollars	1796	36.683	12.465	15	55
Payment offer (system D)	dollars	1796	50.960	16.703	20	75
Perception and attitudes						
Perceived env performance (A)	Likert 1-5	1245	2.965	0.808	1	5
Perceived env performance (B)	Likert 1-5	1189	3.236	0.776	1	5
Perceived env performance (C)	Likert 1-5	1200	3.372	0.784	1	5
Perceived env performance (D)	Likert 1-5	1245	3.460	0.794	1	5
Attitudes towards ES	Likert 1-5	1475	3.119	1.114	1	5
Farm biophysical attributes						
Total land	acres	1521	1151.135	1408.233	2	21500
Sandy soil	binary	1796	0.274	0.446	0	1
Clay soil	binary	1796	0.434	0.496	0	1
Farm attributes						
Moldboard tillage land percent	%	1486	0.067	0.178	0	1
No till tillage land percent	%	1486	0.185	0.244	0	1
Conservation land percent	%	1486	0.342	0.286	0	1
Wheat land percent	%	1486	0.083	0.103	0	0.714
Cover crops land percent	%	1489	0.047	0.149	0	1
PSNT land percent	%	1489	0.050	0.170	0	1
Organic land percent	%	1489	0.010	0.093	0	1
Irrigation land percent	%	1796	0.048	0.165	0	1
Reduced Fertilizer use	binary	1444	0.218	0.413	0	1
Reduced Pesticide use	binary	1442	0.209	0.407	0	1
MAEAP	binary	1371	0.142	0.349	0	1
EQIP	binary	1379	0.298	0.458	0	1
CRP	binary	1421	0.349	0.477	0	1
CSP	binary	1324	0.120	0.325	0	1
Enrollment in any program	binary	1499	0.841	1.004	0	4
Operator attributes						
Age	years	1501	54.780	11.631	21	94
Education	years	1488	13.440	2.562	6	20

Table 5 Consideration decision in the PES programs, weighted by stratum, by cropping systems, 1688 Michigan corn or soybean farmers, 2008

	system A		system B		system C		system D	
	coef	p	coef	p	coef	p	coef	p
Questionnaire Version								
Government	-0.039	0.835	0.170	0.410	0.044	0.837	-0.357	0.094*
Descending sequence	-0.099	0.614	-0.044	0.845	0.555	0.008***	0.352	0.097*
Payment offer	0.022	0.347	-0.022	0.037**	-0.016	0.070*	-0.005	0.377
Perception and attitudes								
Perceived env perf	0.209	0.100*	0.374	0.006***	0.367	0.011**	0.269	0.033**
Attitudes towards ES	0.212	0.033**	0.213	0.040**	0.331	0.000***	0.250	0.003***
Farm biophysical attributes								
Total land	0.000	0.559	0.000	0.726	0.000	0.677	0.000	0.794
Sandy soil	-0.611	0.050**	-0.360	0.288	-0.209	0.486	0.032	0.931
Clay soil	-0.530	0.065*	-0.252	0.416	0.144	0.596	0.002	0.997
Farm management attributes								
Moldboard tillage land percent	-0.702	0.221	-0.825	0.186	-0.776	0.171	-0.680	0.212
No till tillage land percent	0.388	0.414	0.737	0.145	0.268	0.644	0.685	0.294
Conservation land percent	-0.771	0.047**	-0.522	0.190	-0.646	0.095*	-0.715	0.062*
Wheat land percent	0.985	0.247	0.199	0.849	1.781	0.059*	1.794	0.066*
Cover crops land percent	0.182	0.720	-0.671	0.182	-0.485	0.421	0.525	0.461
PSNT land percent	-0.510	0.300	0.022	0.969	0.016	0.980	-0.551	0.280
Organic land percent	-2.090	0.000***	-1.228	0.010***	-1.580	0.044**	-1.790	0.010***
Irrigation land percent	0.286	0.579	0.300	0.581	1.186	0.062*	0.066	0.910
Reduced Fertilizer use	0.522	0.047**	0.574	0.027**	0.612	0.061*	0.192	0.507
Reduced Pesticide use	0.061	0.792	-0.010	0.967	-0.003	0.992	0.321	0.292
MAEAP	-0.438	0.154	-0.148	0.593	-0.513	0.112	-0.843	0.007***
EQIP	-0.205	0.374	-0.192	0.462	0.145	0.605	-0.417	0.092*
CRP	0.304	0.180	0.443	0.080*	0.552	0.061*	0.540	0.100*
CSP	-0.510	0.086*	-0.676	0.033**	-0.510	0.162	-0.408	0.261
Operator attributes								
Age	-0.012	0.184	-0.008	0.361	-0.021	0.026**	-0.023	0.031**
Education	0.122	0.001***	0.029	0.452	0.109	0.005***	0.060	0.200
Constant	-2.151	0.028**	-1.306	0.272	-2.840	0.006***	-1.498	0.291
N	595		540		454		468	
Wald chi	73.12		78.12		70.82		73.69	
p(chi)	0.00		0.00		0.00		0.00	
R square	0.20		0.18		0.22		0.20	
Loglikelihood	-310.85		-289.72		-213.31		-212.20	

Note: ***significant at 99% level, **significant at 95% level, *significant at 90% level

Table 6 Enrollment decision in the PES programs, weighted by stratum, by cropping systems, 1688 Michigan corn or soybean farmers, 2008

	system A		system B		system C		system D	
	coef	p	coef	p	coef	p	coef	p
Questionnaire Version								
Government	-0.148	0.412	0.020	0.905	0.318	0.055*	0.040	0.805
Descending sequence	-0.314	0.104	-0.337	0.049**	-0.487	0.004***	0.000	0.999
Payment offer	0.041	0.024**	0.034	0.000***	0.016	0.012**	0.009	0.064*
Perception and attitudes								
Perceived env perf	0.403	0.002***	0.296	0.017**	0.525	0.000***	0.814	0.000***
Attitudes towards ES	-0.001	0.989	0.086	0.197	0.127	0.104	0.161	0.024**
Farm biophysical attributes								
Total land	0.000	0.021**	0.000	0.010***	0.000	0.075**	0.000	0.210
Sandy soil	0.110	0.678	-0.048	0.862	0.026	0.916	0.019	0.939
Clay soil	-0.111	0.644	-0.190	0.443	-0.130	0.562	0.279	0.211
Farm management attributes								
Moldboard tillage land percent	-1.430	0.005***	-1.280	0.022**	-1.385	0.003***	-1.602	0.001***
No till tillage land percent	0.083	0.848	0.020	0.965	-0.296	0.488	-0.372	0.299
Conservation land percent	0.114	0.719	-0.491	0.150	-0.760	0.020**	-0.247	0.468
Wheat land percent	0.579	0.517	1.636	0.034**	2.675	0.000***	2.111	0.003***
Cover crops land percent	-1.065	0.015**	-1.479	0.001***	-0.990	0.042**	-0.032	0.942
PSNT land percent	0.029	0.929	-0.293	0.401	0.324	0.339	-0.652	0.088*
Organic land percent	-1.751	0.007***	-1.612	0.117	0.164	0.753	-1.223	0.009***
Irrigation land percent	0.158	0.743	0.096	0.810	-0.119	0.795	0.745	0.143
Reduced Fertilizer use	0.095	0.689	0.366	0.094*	0.265	0.135	0.547	0.016**
Reduced Pesticide use	0.031	0.885	0.036	0.859	-0.046	0.803	-0.120	0.564
MAEAP	-0.489	0.015**	-0.169	0.594	-0.401	0.093*	-0.258	0.288
EQIP	0.269	0.211	0.104	0.551	-0.190	0.364	0.471	0.017**
CRP	-0.142	0.432	-0.159	0.427	0.013	0.941	0.435	0.052*
CSP	-0.046	0.853	-0.101	0.653	0.073	0.775	-0.511	0.037**
Operator attributes								
Age	-0.010	0.136	-0.002	0.752	-0.004	0.592	-0.010	0.140
Education	-0.009	0.785	-0.005	0.873	0.048	0.137	0.055	0.060*
Constant	-1.579	0.101	-2.164	0.010***	-3.259	0.000***	-4.573	0.000***
N	886		871		865		896	
wald chi	101.07		90.7		103.13		140.95	
p(chi)	0.00		0.00		0.00		0.00	
R square	0.16		0.16		0.22		0.26	
Loglikelihood	-364.72		-405.10		-433.93		-432.63	

Note: ***significant at 99% level, **significant at 95% level, *significant at 90% level

Table 7 Spatial probit results for enrollment decision in cropping system D by stratum, 1688 Michigan corn or soybean farmers, 2008

	Small (1-99 acres)				Medium (100-499 acres)				Large (500-999 acres)				Very Large (over 1000 acres)			
	spatial		non-spatial		spatial		non-spatial		spatial		non-spatial		spatial		non-spatial	
	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value	Coef	p-value
Government	0.024	0.488	-0.159	0.739	-0.263	0.077*	-0.253	0.182	0.068	0.349	0.073	0.686	0.137	0.161	0.119	0.384
Descending sequence	0.232	0.347	0.113	0.794	0.045	0.403	0.038	0.843	-0.172	0.170	-0.170	0.360	0.024	0.431	0.020	0.884
Payment offer	0.036	0.003***	0.027	0.045**	0.004	0.240	0.004	0.431	0.008	0.094*	0.008	0.173	0.018	0.000***	0.017	0.000***
Perceived env. perf	2.060	0.000***	1.608	0.001***	0.725	0.000***	0.698	0.000***	0.421	0.000***	0.401	0.002***	0.503	0.000***	0.477	0.000***
ES attitudes	0.461	0.017**	0.323	0.121	0.002	0.493	0.007	0.936	-0.056	0.265	-0.043	0.613	-0.038	0.262	-0.035	0.568
Total land	0.003	0.343	0.003	0.735	-0.001	0.064*	-0.001	0.165	0.000	0.406	0.000	0.840	0.000	0.304	0.000	0.660
Sandy soil	-0.094	0.453	-0.116	0.888	0.528	0.037**	0.494	0.096*	0.120	0.346	0.086	0.770	0.580	0.005***	0.565	0.015**
Clay soil	0.342	0.359	0.197	0.799	0.103	0.352	0.089	0.751	0.598	0.016**	0.549	0.041**	0.175	0.206	0.155	0.458
Moldboard tillage	-4.172	0.002***	-3.080	0.033**	-0.888	0.046**	-0.819	0.115	-0.786	0.196	-0.656	0.439	0.614	0.326	0.708	0.551
No till tillage	0.210	0.416	0.406	0.744	-0.578	0.117	-0.528	0.268	-0.273	0.284	-0.268	0.552	0.509	0.067*	0.505	0.157
Conservation tillage	-1.365	0.058*	-0.852	0.281	-0.073	0.425	-0.019	0.960	0.002	0.498	0.047	0.909	0.322	0.157	0.311	0.340
Wheat ratio	4.353	0.023**	3.222	0.077*	1.407	0.035**	1.347	0.099*	0.892	0.200	0.746	0.484	1.915	0.019**	1.816	0.039**
Cover crops ratio	-0.675	0.298	-0.194	0.858	0.319	0.366	0.287	0.767	1.426	0.033**	1.400	0.081*	0.200	0.349	0.156	0.746
PSNT ratio	/[a]	/	/	/	-1.840	0.032**	-1.805	0.059*	0.669	0.091*	0.580	0.230	-0.310	0.195	-0.244	0.471
Irrigation ratio	9.508	0.005***	4.652	0.105	-0.533	0.225	-0.492	0.467	0.079	0.450	0.014	0.982	-0.933	0.008***	-0.989	0.012**
Reduced fertilizer	0.281	0.331	0.300	0.622	0.747	0.004***	0.723	0.009***	0.060	0.405	0.067	0.755	-0.031	0.430	-0.027	0.865
Reduced pesticide	0.641	0.153	0.387	0.491	0.406	0.062*	0.412	0.117	-0.394	0.075*	-0.375	0.154	0.189	0.128	0.193	0.239
Program	0.196	0.255	0.237	0.421	0.210	0.033**	0.209	0.067*	0.311	0.000***	0.304	0.001***	-0.084	0.095*	-0.089	0.180
Age	-0.032	0.061*	-0.024	0.216	-0.017	0.007***	-0.016	0.042**	-0.017	0.046**	-0.015	0.104	0.002	0.371	0.002	0.824
Education	0.172	0.011**	0.124	0.064*	-0.009	0.430	-0.009	0.809	0.030	0.225	0.021	0.598	0.027	0.208	0.028	0.350
intercept	-12.095	0.000***	-9.339	0.001***	-1.928	0.039**	-1.972	0.060*	-2.179	0.035**	-2.107	0.077*	-3.680	0.000***	-3.543	0.000***
rho	0.152	0.001***			0.069	0.011**			0.219	0.000***			0.177	0.004***		
Number of obs			90				224				243				416	
LR chi2			42.78				53.99				43.19				79.98	
Prob > chi2			0.0014				0.0001				0.0019				0	
Pseudo R2			0.4098				0.1765				0.1344				0.1398	
Log-likelihood			-30.803084				-125.97544				-139.10126				-246.02784	

Note: ***significant at 99% level, **significant at 95% level, *significant at 90% level

a. variable is dropped for convergence with limited observations.

Table 8 Spatial coefficient (rho) estimates by system and stratum for enrollment and consideration model, 1688 Michigan corn or soybean farmers, 2008

consideration			enrollment		
	rho	p-level		rho	p-level
system A			**system A**		
stratum 1	0.138	0.005***	stratum 1	0.091	0.010***
stratum 2	0.101	0.010***	stratum 2	0.129	0.003***
stratum 3	0.092	0.005***	stratum 3	0.142	0.003***
stratum 4	0.131	0.006***	stratum 4	0.134	0.001***
system B			**system B**		
stratum 1	0.098	0.006***	stratum 1	0.123	0.007***
stratum 2	0.135	0.005***	stratum 2	0.182	0.001***
stratum 3	0.056	0.017**	stratum 3	0.208	0.002***
stratum 4	0.089	0.006***	stratum 4	0.086	0.008***
system C			**system C**		
stratum 1	0.500	0.000***	stratum 1	0.134	0.003***
stratum 2	0.078	0.006***	stratum 2	0.064	0.013**
stratum 3	0.099	0.009***	stratum 3	0.181	0.001***
stratum 4	0.112	0.008***	stratum 4	0.229	0.001***
system D			**system D**		
stratum 1	0.115	0.009***	stratum 1	0.152	0.001***
stratum 2	0.132	0.008***	stratum 2	0.069	0.011**
stratum 3	0.077	0.010***	stratum 3	0.219	0.000***
stratum 4	0.125	0.004***	stratum 4	0.177	0.004***

Note: ***significant at 99% level, **significant at 95% level

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