IMPACT OF OFF-FARM INCOME ON ADOPTION OF CONSERVATION PRACTICES

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Abstract

Off-farm income has recently been incorporated into the analysis of technology adoption, due to its increasing share in total farm household income in the U.S. Previous studies, however, found inconsistent results with respect to the impact of off-farm income on adoption of conservation practices. The contribution of the current study is to provide a conceptual model which shows that off-farm work has positive impact on adoption of capital incentive practices and negative impact on adoption labor intensive technologies. The results of multivariate probit regression confirms that adoption of injecting manure into the soil, which is a capital intensive practice, is positively and significantly impacted by off-farm work, and adoption of record keeping, which is a labor intensive practice, is negatively and significantly impacted by off-farm work.

Introduction

Livestock production has by-products such as nitrogen and phosphorous. Nitrogen is found in the environment and it is crucial for living organisms. However, ammonia and nitrate forms of nitrogen are dangerous to environmental quality since they can combine with other compounds and create environmental problems (Aillery, *et al*., 2005). Livestock production contributes to emission of nitrogen to water sources through the run-off or leaching of nitrogen in manure, which is spread on the field or through the leakage of manure storage facilities (Aillery, *et al*., 2005). Phosphorus content of animal waste is also a water quality concern (Environmental Protection Agency, 2006). Phosphorus can reach surface waters through runoff from land application of manure and direct deposition (Environmental Protection Agency, 2006). Both nitrogen and phosphorus are important plant nutrients but in water sources they can cause over growth of plants, which causes the amount of dissolved oxygen required by other organisms to decrease, hence causing the death of living organisms in water sources (Aillery, *et al*., 2005).

The National Water-Quality Assessment Program found that the highest concentration of nitrogen and phosphorus in streams occurred in basins with extensive agricultural production and high nitrogen and phosphorus concentration in these streams were mostly due to livestock wastes and manure and fertilizer used for crop production (U.S. Department of Interior, 1999). To minimize the pollution from AFOs, the U.S. Department of Agriculture and Environmental Protection Agency promote the adoption of Comprehensive Nutrient Management Plans (CNMPs) by AFOs. In general, a CNMP identifies the actions that will be followed to meet the nutrient management goals, hence the environmental goals (U.S. Department of Agriculture and Environmental Protection Agency, 1999). Concentrated animal feeding operations (CAFOs), which concentrate animals, feed, manure and urine in the same land area, have been regulated since 1974 under the *Clean Water Act* (Gollehon, *et al.,* 2001).[1] CAFOs are required to follow a CNMP (U.S. Department of Agriculture and Environmental Protection Agency, 1999). However, for AFOs that are not classified as CAFOs, adoption of a CNMP is voluntary. The practices that are included in a CNMP can be adopted without adopting the whole plan. Therefore, the current study will analyze the adoption of individual practices, which can be included in a CNMP, rather than adoption of a CNMP as a whole. Increasing the voluntary adoption of these practices by AFOs requires the barriers to voluntary adoption be known by policy makers and extension staff.

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[1] According to EPA, the threshold for being considered as a CAFO is set by regulations based on the number of animals confined at the operation for a total of 45 days or more in any 12-month period such as 1,000 slaughter and feeder cattle, 700 mature dairy cows and 2,500 swine (Gollehon, *et al*., (2001)). This threshold varies for other livestock species.

Adoption of New Technology and Off-Farm Income

The seminal study by Griliches (1957) spawned the theory that analyzes diffusion of technology. Underpinnings of diffusion theory caused studies to focus on micro-level decisions and to develop adoption theory. Since there are many different factors that impact adoption of a new technology, the studies mostly analyzed a subset of factors and developed theories that combine this small set of factors and adoption behavior. Therefore, instead of a one big theory that explains all aspects of technology adoption, it is possible to see different theories that explain a part of adoption behavior. While the early adoption theories focused on profitability, subsequent studies have found that farm size, risk and uncertainty, information, human capital and labor supply also affect adoption.

Off-farm work has become a significant source of income for farm families. Mishra, *et al*. (2002) report that, in the U.S., 71 percent of farm households had either the operator, spouse or both have off-farm work in 2002. Hence, the share of off-farm income in farm household income rose from roughly 50% in 1969 to 90% in 1999 (Mishra, *et al.*, 2002). The conventional thinking was that the off-farm work was a temporary source of income. However, Ahearn and El-Osta (1993) showed that farm families continue to have off-farm income throughout the year. Therefore, off-farm work permanently exists in the life of farm households. Farmers use off-farm work to avoid the income variability due to risk associated with farm income (Huffman, 1980; Barlett, 1986; Mishra, *et al.*, 2002).

Given the importance of off-farm work to farm households, off-farm income has been recently added to the analysis of technology adoption. These studies can be analyzed in two groups. Some of the studies analyze the joint decision making of off-farm work participation and adoption of new technology and test whether these two decisions are done simultaneously, sequentially or independently. Other studies analyze how having off-farm work impacts the adoption of new technology by incorporating off-farm work as an explanatory variable into the econometric analysis of adoption of new technology. The current study falls into the second group.

The empirical results of previous studies and the study by Núñez (2005) showed that off-farm income level of farmers has a significant impact on their decision to adopt new technologies. However, the way off-farm income affects the adoption decision is not clear. There can be two effects; 1) farmers with off-farm income have more financial capability to adopt new technologies, 2) farmers with off-farm income do not have enough time to adopt new technologies. Hence, depending on capital and time requirements of the technology, the off-farm income can be a factor that intensifies adoption or a factor that defers adoption. The previous studies did not have a behavioral model that distinguishes the two different impacts of off-farm income.

The contribution of the current study is to provide a behavioral model that represents the impact of off-farm income on adoption of new technologies by providing the conditions under which capital intensive and management intensive technologies are more likely to be adopted.

Analytical Framework

To represent the household's voluntary decision regarding technology adoption, a household utility maximization model is constructed. The current model is extension of the agricultural household models by Huffman (1980) and Cornejo, *et al*. (2005). The household problem can be represented as;

$$(1) \quad \max_{C, L_e, L_a, K_a} U\left(C, L_e, E(L_a, K_a)\right)$$

$s.t.$

$$(2) \quad P_c.C + r.K + r.K_a + W.L_{on} \leq P_q.Q + W.L_{of}$$

$$(3) \quad L_{on} + L_{of} + L_a + L_e \leq 24$$

$$(4) \quad Q \leq F(K, L_{on})$$

where, U (.) is the utility function of the household, C is the consumption, L_e is leisure, E(.) is the level of environmental quality, which is an increasing function of amount of labor, L_a, and amount of capital, K_a, reserved for adoption of conservation practices.

The budget constraint is represented in equation (2). P_c is the price for the consumption good, P_q is the price for the farm output, Q is the farm output and W is the wage rate for the off-farm work. r is the market interest rate and K is the capital for production activities. The time constraint is represented in equation (3). The total amount of time available for the household is 24 hours. L_{on} is the amount of time provided for on-farm activities, L_{of} is the time devoted to off-farm work. For the current model both on-farm labor and off-farm labor are exogenous to model, to reflect that the situation that labor devoted to adoption of new conservation technologies is determined after on-farm and off-farm labor decisions are made.

The technology constraint is reflected in equation (4). Where, F(.) is the neo-classical production, which is an increasing function of amount of capital K, and amount of on-farm labor, L_{on}. To maximize consumption, farmers will always produce at the level available by the technology; hence the technology constraint is always binding;

$Q = F(.)$.

To find the solution to the household problem, the structured Langrangian becomes;

$$L:\max_{C,L_e,L_a,K_a} U\left(C,L_e,E(L_a,K_a)\right)+\lambda\left(P_q.F(K,L_{on})+W.L_{of}-P_c.C-r.K-r.K_a-W.L_{on}\right)$$
$$+\mu\left(24-L_{on}-L_{of}-L_a-L_e\right)$$

the first order conditions become;

(5) $\frac{\partial L}{\partial C}:U_1'-P\lambda\leq 0 \qquad C^*\geq 0$

(6) $\frac{\partial L}{\partial L_e}:U_2'-\mu\leq 0 \qquad L_e^*\geq 0$

(7) $\frac{\partial L}{\partial L_a}:U_3'\frac{\partial E(.)}{\partial L_a}-\mu\leq 0 \qquad L_a^*\geq 0$

(8) $\frac{\partial L}{\partial K_a}:U_3'\frac{\partial E(.)}{\partial K_a}-r\lambda\leq 0 \qquad K_a^*\geq 0$

(9) $\lambda\left(P_q.F(K,L_{on})+W.L_{of}-P_c.C-r.K-r.K_a-W.L_{on}\right)=0$

(10) $\mu\left(24-L_{on}-L_{of}-L_a-L_e\right)=0$

where equations (5)-(8) are the first order conditions for consumption, leisure, labor and capital for adoption of new technology. Equations (9) and (10) reflect that either the constraints hold with equality, hence the inside of the parentheses equal zero and the Langrangian multipliers λ and μ are non-zero, or the Langrangian multipliers are zero and inside of the parentheses are positive. C^*, L_e^*, L_a^*, K_a^* are the optimal decision variables. U_1', U_2', U_3' represent first order partial derivatives of the utility function with respect to consumption, leisure and environmental quality.

Either the assumption that farmers will always have a positive amount of consumption and leisure, or a strict concavity assumption of the utility function (i.e. logarithmic utility function), will lead equation (5) and (6) to hold with equality. Hence, the values of the Langrangian multipliers λ and μ are; $\lambda = \frac{U_1'}{P_c}$, $\mu = U_2'$.

The impact of off-farm income on adoption of two types of technologies; labor intensive and capital intensive are analyzed in two different cases.

Labor Intensive Technology

In this case we assume there is a positive critical amount of labor, L_a^C, that is required by the new technology. Hence, the necessary condition for a farmer to adopt the labor intensive new technology is L_a^* to be at least as big as the critical amount of labor required by the new technology. To show the impact of off-farm income on L_a^* we look at the case where only the time constraint is binding. Using $\mu = U_2'$, the first order condition (6) of L_a^* for an interior solution becomes[2];

$$(11) \quad U_3' \frac{\partial E(.)}{\partial L_a} = U_2' \qquad L_a^* > 0$$

Equation (11) states that, at the optimum, the marginal utility from environmental quality will be equal to the marginal utility from leisure. To find the impact of off-farm income on the amount of labor devoted the adoption, we take the derivative of (11) and as only the time constraint is binding, only L_a^* are L_e^* assumed to be implicitly functions of L_{of} ;

[2] The strict concavity assumption of the utility function is used. Even an interior solution may not mean adoption as the solution may still be less than the critical value of the labor required by the new technology. The similar results can be obtained for a corner solution, if the strict concavity assumption is dropped.

(12) $U_3''\left(\frac{\partial E(.)}{\partial L_a}\right)^2 \frac{dL_a^*}{dL_{of}} + U_3' \frac{\partial^2 E(.)}{\partial L_a^2} \frac{dL_a^*}{dL_{of}} - U_2' \frac{dL_e}{dL_{of}} = 0$

which leads to

(13) $$\frac{dL_a^*}{dL_{of}} = \frac{U_2'' \frac{dL_e}{dL_{of}}}{U_3''\left(\frac{\partial E(.)}{\partial L_a}\right)^2 + U_3' \frac{\partial^2 E(.)}{\partial L_a^2}} < 0$$

Hence, as amount of off-farm work increases, the farmer devotes less labor to adoption of a new technology, hence decreasing the probability that the new technology is adopted. In the above equation, using the strict concavity of the utility function and the environmental quality function; the second derivatives of the utility function and the environmental quality function are strictly negative, making the denominator negative. The sign of $\frac{dL_e}{dL_{of}}$ is positive due to the binding time constraint; hence the numerator is positive, making the total effect of off-farm work on L_a^* negative.

Capital Intensive Technology

In this case we assume there is a positive critical amount of capital, K_a^C, that is required by the new technology. Hence, the necessary condition for a farmer to adopt the capital intensive new technology is K_a^* to be at least as big as the critical amount of capital required by the new technology. To show the impact of off-farm income on K_a^* we look to the case where only the budget constraint is binding. Using $\lambda = \dfrac{U_1'}{P_c}$, the first order condition (8) of K_a^* for an interior solution becomes;

$$(14) \quad U_3' \frac{\partial E(.)}{\partial K_a} = \frac{U_1'}{P_c} \mathrm{r} \qquad K_a^* > 0$$

Equation (14) states that, at the optimum, the marginal utility from environmental quality will be equal to the marginal utility from consumption. To find the impact of off-farm income on the amount of capital devoted the adoption, we take the derivative of (14) and as only the budget constraint is binding, only K_a^* and C^* are assumed to be implicitly functions of L_{of};

$$(15) \quad U_3''\left(\frac{\partial E(.)}{\partial K_a}\right)^2 \frac{dK_a^*}{dL_{of}} + U_3' \frac{\partial^2 E(.)}{\partial K_a^2} \frac{dK_a^*}{dL_{of}} - U_1' \frac{r}{P_c} \frac{dC}{dL_{of}} = 0$$

which leads to

$$(16) \quad \frac{dK_a^*}{dL_{of}} = \frac{U_1'' \dfrac{r}{P_c} \dfrac{dC}{dL_{of}}}{U_3''\left(\dfrac{\partial E(.)}{\partial K_a}\right)^2 + U_3' \dfrac{\partial^2 E(.)}{\partial K_a^2}} > 0$$

Hence, as the amount of off-farm work increases, the farmer devotes more capital to adoption of the new technology, hence increasing the probability a new technology will be adopted. In the above equation, using the strict concavity of the utility function and the environmental quality function; the second derivatives of the utility function and the environmental quality function are strictly negative, making the denominator negative. The sign of $\dfrac{dC}{dL_{of}}$ is positive due to the binding time constraint; hence the numerator is also negative, making the total effect of off-farm work on K_a^* negative.

The model leads to empirical hypotheses that will be tested using the data from a survey;

1. If the new technology is labor intensive, the farmers with off-farm work are less likely to adopt the technology than the farmers who do not have off-farm work.
2. If the new technology is capital intensive, the farmers with off-farm work are more likely to adopt the technology than the farmers who do not have off-farm work.

To test the hypotheses (1) and (2), a multivariate probit model will be used. Model specifications will be introduced in the next section.

Empirical Model

The previous studies that analyzed the impact off-farm income and adoption of multiple practices revealed the importance of separating off-farm work decisions of the farm operator and the spouse and using either bivariate or multivariate probit regression models.

Huffman and Lange (1989) examine the off-farm decisions of the husband and wife jointly. The main finding of this study is that the estimates of the explanatory variables are significantly different for husband and wife. Hence, studies that do not account for the differences in off-farm work participation of husband and wife will have serious specification errors (Huffman and Lange, 1989). For this reason, the current study will incorporate the off-farm work of both the farm operator and the spouse.

Most of the empirical studies focus on either adoption of an individual practice within a multi-component technology package or adoption of the package as a whole (Khanna, 2001; Dorfman, 1996). The studies that analyze individual practices within a package, treat adoption of each practice as independent. The single equation estimation of adoption of individual practices within a package ignores the correlation among the adoption of inter-related practices (Khanna, 2001; Wozniak, 1984). The correlation might arise from either the unobserved factors, which might impact the adoption of all the practices in the package, or the adoption of one practice may be conditional on adoption of another practice (Khanna, 2001; Dorfman, 1996). Khanna (2001) explains that when adoption decisions of inter-related technologies are modeled as independent single equations, the estimates for these single equations will be inefficient; hence the variance of the estimated coefficients will be large.

In the current study, the producers who have a comprehensive nutrient management plan are expected to adopt practices such as soil testing, grass filters and record keeping jointly. Hence, adoption decisions for the practices are expected to be correlated. Previous studies by Dorfman (1996), Wozniak (1984) and Khanna (2001) have used bivariate and multivariate probit models to analyze the adoption of inter-related technologies.

In general the adoption decision can be represented as;

$y_i = 1 \quad \text{if practice is adopted, 0 otherwise}$

Hence, for the case of a single technology, the factors that impact adoption of the technology can be analyzed using univariate probit / logit models. In this case the probability of adopting the technology, conditional on the explanatory variables, can be represented as;

$$P(y = 1 | x_1, x_2, ..., x_k) = G(XB)$$

Where $x_1, x_2, ..., x_k$ are k explanatory variables and G(.) is the cumulative distribution function. In case of the probit model, the standard normal distribution function is used for G(.) and for the logit model the logistic cumulative distribution function used for G(.) (Greene, 2003).

The bivariate probit model is reviewed briefly to clearly show the difference in the structure between the univariate model described above and the multivariate probit model. Following Greene (2003), for the case of adoption of two technologies;

$$y_1 = X_1\beta_1 + \varepsilon_1, \quad \mathrm{y}_1 = 1 \text{ if technology 1 is adopted, 0 otherwise,}$$

$$y_2 = X_2\beta_2 + \varepsilon_2, \quad \mathrm{y}_2 = 1 \text{ if technology 2 is adopted, 0 otherwise,}$$

$$\mathrm{E}[\varepsilon_1 | X_1, X_2] = \mathrm{E}[\varepsilon_2 | X_1, X_2] = 0,$$

$$Var[\varepsilon_1 | X_1, X_2] = \mathrm{Var}[\varepsilon_2 | X_1, X_2] = 1,$$

$$Cov[\varepsilon_1, \varepsilon_2 | X_1, X_2] = \rho$$

The errors are assumed to have a bivariate normal distribution with expected values equal to zero and variances equal to one. The correlation between adoption of the two technologies is represented by ρ, the covariance between the error terms. If ρ is found to be significant, its sign shows the direction of the correlation (Greene, 2003; Khanna, 2001).

The multivariate probit model is the extension of the bivariate model mentioned above by adding more equations and by having the error terms have a multivariate normal distribution. Four technologies will be examined in this study and the econometric model is;

$$y_1 = X_1\beta_1 + \varepsilon_1, \quad \mathrm{y}_1 = 1 \text{ if injecting manure is adopted, } \quad \text{0 otherwise,}$$

$$y_2 = X_2\beta_2 + \varepsilon_2, \quad \mathrm{y}_2 = 1 \text{ if grass filter is adopted, } \quad \text{0 otherwise,}$$

$$y_3 = X_3\beta_3 + \varepsilon_3, \quad \mathrm{y}_3 = 1 \text{ if soil test is adopted, } \quad \text{0 otherwise,}$$

$$y_4 = X_4\beta_4 + \varepsilon_4, \quad \mathrm{y}_4 = 1 \text{ if record keeping is adopted, } \quad \text{0 otherwise,}$$

Data

A mail survey of 3014 farmers, including both CAFOs and AFOs, was conducted in Iowa and Missouri in Spring 2006. Farmers were stratified by farm sales and by type of livestock. Farmers with farm sales less than $10,000 were not sampled. This eliminates most retirement / lifestyle farmers (Hoppe, 2006). In designing the survey, the methodology discussed by Dillman (2000) was followed. The questions were designed to learn whether farmers have adopted the chosen conservation practices and how the farmer's and the farm's characteristics impacted the adoption decision. The effective response rate for the survey was 37.4 percent. For the regression analysis, CAFOs are excluded from the data set to focus on factors affecting voluntary adoption.

The summary statistics for the data are presented in Table 1. The average age of farmers in the survey was 51. Fifty one percent of the survey respondents were from Iowa and the rest were from Missouri. Forty three percent of the survey respondents had a high school degree (the base category for the regression analysis). Seventy percent of respondents had off-farm income. Thirty five percent of the respondents had farm sales, which includes both crop and livestock sales, between $100,000 and $249,999 (the base category for the regression analysis). About 83 percent of the farmers indicated that they expect to continue farming at their current farm in the next 5 years and 54 percent of the farmers indicated that they expect to increase their livestock numbers. Only 18 percent of the farmers had an Environmental Quality Incentives Program (EQIP) contract through the Natural Resources Conservation Service.

About 14 percent of the farm operators had seasonal off-farm work and 22 percent had year round off-farm work. These numbers are 7 percent and 50 percent for the spouse, respectively. Only 19 percent of the survey respondents indicated that off-farm work interferes with the timing of the farming operations, while 50 percent answered no and the rest indicated that the question was not applicable to them. About 48 percent of the farmers hired non-family labor in 2005.

In terms of the practices used as the dependent variables in the multivariate probit regression, the adoption rate was 21 percent for injecting manure, 61 percent for grass filter, 72 percent for soil test, and 37 percent for record keeping.

Regression Results and Discussion

Four dependent variables used in the regression analysis were classified; injecting manure into the soil is categorized as a capital intensive technology since it requires specific equipment, using grass filter systems as a buffer around water sources is intermediate, record keeping is labor intensive, and soil testing is categorized as neither capital nor labor intensive. Since the current overall adoption rate is lower for injecting manure and record keeping, they have higher number of significant independent variables than grass filter and soil test.

The p-value of the Wald test statistic for overall significance of the regression is 0.00, which shows that the multivariate probit regression is significant overall. The multivariate probit regression results are given in Table 2. Some of the variables are discussed below.

Age

Age represents the experience and innovativeness of the farmer, and also captures the differences in the present value of future income between younger and older farmers. The empirical results of previous studies show both positive and negative relationships between age and adoption of new technology. In the current study, age in years has a negative and significant effect on adoption of for grass filters and soil testing. This shows that younger farmers are more likely to adopt grass filters and soil test. Age is not significant for injecting manure and record keeping.

Education

Education is assumed to provide skills to augment and use information, hence increasing the allocative ability of the individuals (Huffman, 1974; Wozniak, 1984). The allocative ability is the human's ability to acquire and use information relating to the production technology (Welch, 1970). Overall, Wozniak (1984) hypothesized that education enhances the innovative ability of individuals and leads to efficient adoption decisions.

Some of the previous studies on adoption of new technology found that the probability of adopting the new technology is increasing with level of education (Wozniak ,1984 ; Abdulai and Huffman, 2005). However, some of the studies did not find a significant relationship between human capital and adoption of new technology (Upadhyay, *et. al*., 2002 ; Soule, *et al*., 2000). Khanna (2001) found that adoption of soil testing is not affected by the education of the farmer.

In the current study, farmers with high school education are more likely to inject manure than farmers with some college or vocational education or farmers with graduate degree. There was no significant difference for those with a bachelor's degree. For grass filters, farmers with a high school degree are more likely to adopt than farmers with some college or vocational education. Education is found to be insignificant for soil testing. However, for record keeping, farmers with a high school degree are found to be more likely to adopt than farmers with graduate degree and farmers with less than high school degree.

Finding high school graduates to be more likely to adopt a practice than farmers with education less than high school is consistent with the literature. However, finding high school graduates are more likely to adopt a practice than farmers with vocational or graduate education shows that factors other than innovativeness may be impacted by education. Also, it could be that education is more important when practices are complicated and most farmers indicated that they did not consider these practices to be complicated (Table 1).

Off-Farm Work

If the farm operator has seasonal off-farm work, then the farmer is more likely to adopt injecting manure and grass filters than a farmer who has no off-farm work. Also, if the farm operator has year round off-farm work, the farmer is less likely to adopt record keeping than a farmer who has no off-farm work. For soil testing, however, it is found that, if the farm operator has seasonal off-farm work, then the farmer is more likely to adopt soil testing than a farmer with no off-farm work. The same result is found for the impact of the spouse's seasonal work.

Comparison of the regression results with the behavioral model predictions reveals that there is support for the model in the cases of injecting manure, grass filters and record keeping. Hence, we provide evidence that adoption of capital intensive practices are positively impacted by the off-farm work of the farmer and adoption of labor intensive technologies are negatively impacted by the off-farm work of the farmer. Since, soil testing is neither capital intensive nor labor intensive, it is probably the case that factors other than income and time availability impact adoption of soil testing.

Off-Farm Income

Off-farm income is found to positively impact adoption of practices that require financial sources. However, off-farm income is also assumed to be negatively associated with farm size/sales. This applies especially to the large farms requiring high management intensity, as high management intensity will require more on-farm work and leave less time available to off-farm work. In the current study, farmers with an off-farm income level of $10,000-$24,999 are found to be more likely to inject manure and adopt grass filters than farmers with an off-farm income level of $25,000-$49,999. For soil testing, there is no statistically significant difference between the base category and the other off-farm income levels.

Farm-Sales

Farm size has been included in the analysis of adoption of new technology due to its relationship with fixed investment cost, credit constraint, information cost and human capital (Feder, *et al*., 1985). The impact of farm size on adoption of new technology can be analyzed through its association with different factors; economies of scale in production; access to credit, and economies of scale in information costs.

Some of the early studies show a positive relationship between adoption of new technology and farm size. This result is attributed to economies of scale gained by large farms due to fixed costs of equipment (Khanna, 2001 ;Qaim and de Janvry, 2003 ; Abdulai and Huffman, 2005). Barham, *et al*. (2004) found that adoption of rBST increases as the size of the farm increases, since the price of the rBST was high, only large farms could afford it. Participation in a conservation program and farm size is found positively related by Hua, *et al*. (2004) and Chang and Boisvert (2005). The studies that found either statistically insignificant or negative relationships between farm size and adoption of new technology are mostly attributed to non-existence of economies of scale in the technology to be adopted (Soule, *et al*., 2000; Khanna, 2001 ; Hua, *et al*., 2004).

In the current study, there is a statistically significant and positive relationship between adoption of injecting manure and farm sales level. Farmer with farm sales levels of $250,000-$499,999 and $500,000 + are more likely to adopt injecting manure than farmers with farm sales of $100,000-$249,999. For grass filters and soil testing, farmers with farm sales of $10,000 - 9,999 are less likely to adopt than farmers with farm sales of $100,000-$249,999.

Environmental Perceptions

Perceptions and attitudes of farmers about the environmental problem and the technology to be adopted have been incorporated into studies to examine the impact of environmental awareness and stewardship on adoption of conservation practices. Upadhyay *et. al*.(2002) mention that environmental perceptions will not result in action unless there are economic or other benefits. Previous studies found both positive and negative relationships between perceptions and adoption of conservation practices (Hua, *et al*. 2004 ; Upadhyay, *et. al*., 2002).

In the current study, it is found that the more the smell of manure bothers the farmer or his / her family, the more likely the farmer tests soil. The more the smell of manure bothers the farmer's neighbor, the more likely the farmer adopts injecting manure. The more concerned a farmer is about the water quality of streams and lakes in the farmer's county, the more likely to adopt record keeping, but the less likely to adopt injecting manure and soil testing. The more a farmer agrees that agricultural regulations regarding water quality will become stricter in the next five years, the less likely the farmer adopts injecting manure. The more transportation costs and time affect which of the farmer's fields receive manure, the less likely the farmer adopts soil testing and record keeping.

Perceptions about the Practices

There is a statistically significant positive relation between perceived profitability of the practices and adoption. The more a farmer agrees that the practice is profitable, the more likely the farmer adopts injecting manure, grass filters, soil testing and record keeping. Perceptions about improving water quality and being time consuming were found significant only for grass filters. The more a farmer agrees that the practice improves water quality, the more likely the farmer adopts grass filters. The more a farmer agrees that the practice is time consuming, the less likely the farmer adopts grass filters. A perception that the practice is complicated is significant for injecting manure and soil testing. The more a farmer agrees that the practice is complicated, the less likely the farmer adopts injecting manure and soil testing.

Conclusion

Results of the current study reveal that, to measure the impact of off-farm income on adoption of conservation practices it is important to know the capital and labor requirements of these practices. The behavioral model of the current study predicted that adoption of capital intensive practices is positively impacted by off-farm work, due to creation of extra income, and adoption of labor intensive technologies is negatively impacted by off-farm work, due to a lack of time. The multivariate probit regression of injecting manure, grass filters, soil testing and record keeping supports the predictions of the behavioral model.

Since the importance of off-farm income is expected to increase in the future, programs and policies to increase the adoption of environmental practices need to take this into account. Time to acquire information and perform practices is increasingly scarce. For farmers with full-time jobs, meeting with NRCS agents during the day is problematic. EQIP and other incentive programs can help capital-constrained farmers but the application process is time-consuming and requires interaction with NRCS agents. The design of new technologies should take into account the opportunity cost of farmers' time as well as the out of pocket costs.

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Table 1: Summary Statistics of Variables

Variable	N	Mean	Std. Dev.	Range
Age	912	51.87	11.33	23-93
IOWA	919	0.51	0.5	0-1
MISSOURI	919	0.49	0.5	0-1
Education				
Less than High School	913	0.11	0.31	0-1
High School (Base Category)	913	0.43	0.5	0-1
Some College or Vocational School	913	0.28	0.45	0-1
Bachelor Degree	913	0.16	0.37	0-1
Graduate Degree	913	0.02	0.13	0-1
Off-farm Income				
None	872	0.3	0.46	0-1
$0 - $9,999	872	0.13	0.34	0-1
$10,000-$24,999 (Base Category)	872	0.16	0.37	0-1
$25,000 - $49,999	872	0.26	0.44	0-1
$50,000 - $99,999	872	0.12	0.33	0-1
$100,000 +	872	0.03	0.16	0-1
Farm Sales				
$0 - $9,999	892	0.03	0.17	0-1
$10,000 - $99,999	892	0.28	0.45	0-1
$100,000-$249,999 (Base Category)	892	0.35	0.48	0-1
$250,000 - $499,999	892	0.19	0.39	0-1
$500,000 +	892	0.15	0.36	0-1
Environmental Perceptions				
Smell of Manure Bothers Me or Fam.	903	2.6	1.1	0-5
Smell of Maunre Bothers My Neighbors	895	2.8	1.1	0-5
Not Sure How Crops Respond to Manure	892	2.1	1.2	0-5
Concerned about the Water Quality	901	4.2	1.1	0-5
Managing Manure Improves Water Quality	903	4.2	1.0	0-5
Regulations about Water Quality will be Stricter	909	4.0	1.0	0-5
Continue Farming in Next 5 Years YES	868	0.9	0.3	0-1
Continue Farming in Next 5 Years NO (Base Category)	868	0.03	0.17	0-1
Continue Farming in Next 5 Years NOT SURE	868	0.1	0.3	0-1
Expand Livestock Numbers in Next 5 Years YES	850	0.3	0.46	0-1
Expand Livestock Numbers in Next 5 Years NO (B. C.)	850	0.45	0.5	0-1
Expand Livestock Numbers in Next 5 Years NOT SURE	850	0.24	0.43	0-1
Perceptions about the Practice				
Inject Manure				
Profitable	816	3.51	1.29	0-5
Improve Water Quality	807	3.87	1.11	0-5
Time Consuming	794	3.26	1.20	0-5
Complicated	792	2.81	1.18	0-5
Grass Filter				

Profitable	830	3.55	1.26	0-5
Improve Water Quality	836	4.33	0.96	0-5
Time Consuming	812	2.79	1.22	0-5
Complicated	807	2.48	1.15	0-5
Soil Test				
Profitable	839	4.17	1.11	0-5
Improve Water Quality	803	4.02	1.08	0-5
Time Consuming	800	2.97	1.26	0-5
Complicated	792	2.30	1.19	0-5
Record Keeping				
Profitable	836	3.34	1.31	0-5
Improve Water Quality	820	3.46	1.16	0-5
Time Consuming	823	3.57	1.20	0-5
Complicated	815	3.06	1.22	0-5
Influence on Agricultural Decision				
Bank	884	2.3	1.2	0-5
Contractor	879	1.8	1.1	0-5
University	885	2.3	1.1	0-5
NRCS	886	2.6	1.2	0-5
Environmental Quality Incentives Program	921	0.18	0.39	0-1
Manure Handling				
Solid Handling	902	0.58	0.49	0-1
Liquid Handling (Base Category)	902	0.13	0.34	0-1
Solid and Liquid Handling	902	0.26	0.44	0-1
Total Animal Units	896	562.76	802.01	5-9800
Species Dummy				
Dairy	905	0.2	0.4	0-1
Beef Cow	905	0.2	0.4	0-1
Beef Cattle	905	0.14	0.35	0-1
Swine	905	0.27	0.44	0-1
Poultry	905	0.07	0.25	0-1
Turkey	905	0.11	0.31	0-1
Other	905	0.02	0.13	0-1
Contributes Significantly to Farm Work				
Farm Operator	904	0.97	0.18	0-1
Spouse	751	0.57	0.5	0-1
Other Family Member	921	0.41	0.49	0-1
Off-Farm Work				
Farm Operator Seasonal	891	0.14	0.37	0-1
Farm Operator Year Round	890	0.22	0.42	0-1
Spouse Seasonal	748	0.07	0.26	0-1
Spouse Year Round	747	0.5	0.5	0-1
Hours worked Off the Farm (Including both those who work off the farm and those who don't)				
Farm Operator	859	11.69	18.72	0-100
Spouse	700	19.67	19.83	0-85
Other Family Member	919	7.68	18.75	0-100
Off-farm work interfere farm work YES	868	0.19	0.39	0-1
Off-farm work interfere farm work NA	867	0.31	0.46	0-1
Hire Non-Farm Labor Dummy	897	0.48	0.5	0-1

Dependent Variables				
Injecting Manure	873	0.21	0.4	0-1
Grass Filter	828	0.61	0.5	0-1
Soil Test	811	0.72	0.4	0-1
Record Keeping	869	0.37	0.5	0-1

Table 2: Results of the Multivariate-Probit Regression

	INJECT MANURE		GRASSFILTER		SOIL TEST		RECORD KEEPING	
Variables	**Coeff.**	**p-value**	**Coeff.**	**p-value**	**Coeff.**	**p-value**	**Coeff.**	**p-value**
Age	-0.09	0.29	-0.11	0.07	-0.24	0.00	-0.04	0.60
Age^2	0.00	0.56	0.00	0.11	0.00	0.01	0.00	0.82
Iowa	0.69	0.10	-0.13	0.56	0.53	0.05	0.28	0.31
Education								
Less than High School	-1.55	0.02	-0.49	0.21	-0.33	0.48	-1.11	0.03
Some College or Vocational School	-1.04	0.00	-0.40	0.05	0.21	0.42	0.35	0.13
Bachelor Degree	0.13	0.71	0.06	0.80	0.15	0.64	-0.12	0.72
Graduate Degree	-6.67	0.00	-0.15	0.83	-0.25	0.66	-6.05	0.00
Off-farm Income								
None	-0.13	0.83	0.15	0.71	0.35	0.49	0.43	0.32
$0 - $9,999	0.25	0.56	-0.32	0.33	-0.34	0.37	0.53	0.17
$25,000 - $49,999	-1.03	0.03	-0.45	0.09	-0.05	0.88	0.15	0.63
$50,000 - $99,999	-1.00	0.14	0.09	0.79	-0.56	0.22	-0.20	0.65
$100,000 +	-0.62	0.59	-0.88	0.27	-0.99	0.13	-5.51	0.00
Contributes Significantly to Farm Work								
Spouse	-0.19	0.55	-0.22	0.23	-0.18	0.45	0.06	0.77
Other Family Member	0.05	0.85	0.40	0.02	0.18	0.44	0.00	0.99
Off-Farm Work								
Farm Operator Seasonal	0.87	0.01	0.46	0.05	1.27	0.00	-0.05	0.84
Farm Operator Year Round	0.50	0.32	-0.27	0.36	-0.08	0.85	-0.71	0.07
Spouse Seasonal	0.37	0.48	0.14	0.73	1.03	0.06	-0.26	0.60
Spouse Year Round	0.20	0.65	0.07	0.81	0.37	0.26	0.03	0.91
Off-farm work interfere Yes	0.18	0.66	0.80	0.00	-0.20	0.55	0.34	0.29
Off-farm work interfere NA	-0.35	0.30	0.04	0.86	-0.38	0.18	-0.20	0.44
Hire Non-Farm Labor Dummy	-0.16	0.62	-0.24	0.20	0.22	0.33	0.10	0.62
Farm Sales								
$0 - $9,999	-4.95	0.00	0.85	0.25	-0.11	0.90	2.01	0.00
$10,000 - $99,999	-0.16	0.73	-0.57	0.01	-0.48	0.10	0.40	0.17

$250,000 - $499,999	1.12	0.00	0.06	0.79	-0.29	0.32	-0.08	0.79
Farm Sale$500,000 +	2.08	0.00	0.56	0.12	0.09	0.86	0.12	0.73
Environmental Perceptions								
Smell of Manure Bothers Me or My Family	-0.15	0.41	0.07	0.49	0.26	0.04	0.04	0.70
Smell of Manure Bothers My Neighbors	0.42	0.05	-0.11	0.29	0.15	0.31	-0.04	0.77
Not Sure How Crops Respond to Manure	-0.11	0.50	-0.10	0.26	-0.15	0.15	-0.06	0.58
Concerned about the Water Quality	-0.42	0.02	0.04	0.68	-0.22	0.08	0.29	0.01
Managing Manure Improves Water Quality	0.13	0.53	-0.10	0.43	-0.07	0.63	0.04	0.77
Regulations will be Stricter	-0.47	0.01	-0.13	0.27	-0.16	0.16	-0.19	0.14
Transportation Costs and Time Affect Which of My Fields Receive Manure	-0.18	0.11	0.02	0.73	-0.21	0.00	-0.22	0.01
Continue Farming Yes	-0.25	0.73	-0.22	0.68	0.60	0.18	1.30	0.01
Continue Farming Not Sure	0.12	0.89	-0.11	0.85	-0.08	0.89	1.41	0.04
Expand Livestock Numbers Yes	0.17	0.65	-0.24	0.25	0.41	0.14	-0.33	0.19
Expand Livestock Numbers Not Sure	0.24	0.46	-0.22	0.34	0.16	0.59	-0.23	0.40
Perceptions about the Practice								
Profitable	0.86	0.00	0.37	0.00	0.57	0.00	0.54	0.00
Improve Water Quality	0.27	0.24	0.23	0.05	0.07	0.54	-0.04	0.79
Time Consuming	0.14	0.29	-0.22	0.05	-0.14	0.17	-0.06	0.61
Complicated	-0.29	0.06	0.02	0.86	-0.28	0.01	-0.08	0.53
Influence on Agricultural Decision								
Bank	0.08	0.57	0.12	0.14	-0.02	0.84	-0.17	0.10
Contractor	0.15	0.37	-0.08	0.42	-0.09	0.43	0.03	0.79
University	-0.18	0.29	-0.05	0.67	0.23	0.03	0.12	0.28
NRCS	-0.08	0.57	0.16	0.11	0.15	0.22	0.08	0.43
EQIP	-0.62	0.16	0.07	0.78	0.45	0.17	0.03	0.91
Manure Handling								
Solid Handling			0.61	0.08	0.01	0.98	-1.73	0.00
Solid and Liquid Handling			0.34	0.31	-0.24	0.61	-1.47	0.00
Total AU	0.00	0.41	0.00	0.27	0.00	0.00	0.00	0.13

Species Dummy								
Dairy	-1.80	0.00	-0.46	0.12	-0.09	0.83	-0.32	0.34
Beef Cow	-2.49	0.00	-0.41	0.19	1.48	0.00	-0.42	0.24
Beef Cattle	-2.51	0.00	-0.25	0.49	0.57	0.17	-0.70	0.08
Poultry	-2.45	0.00	-0.90	0.08	-0.43	0.48	1.20	0.04
Turkey	-1.74	0.00	-0.92	0.06	0.41	0.49	1.01	0.06
Other	-1.09	0.03	0.25	0.63	-0.06	0.93	0.98	0.09
Constant	2.09	0.45	2.70	0.13	5.45	0.03	-0.65	0.78