# Off-Farm Employment Effects on Adoption of Nutrient Management Practices

**Haluk Gedikoglu, Laura McCann, and Georgeanne Artz**

Off-farm income as a share of total farm household income has been increasing. Previous studies found inconsistent results regarding the impact of off-farm income on adoption of conservation practices. We test the hypothesis that off-farm employment has a positive impact on adoption of capital incentive practices and a negative impact on adoption of labor-intensive practices. The results confirm that adoption of injecting manure into the soil, a capital-intensive practice, is positively and significantly impacted by off-farm employment of the operator. However, off-farm employment variables had no effect on adoption of record keeping.

***Key Words:*** adoption, nutrient management, off-farm income

Animal feeding operations[1] (AFOs), and livestock operations more generally, are significant sources of water pollution in the United States (U.S. Environmental Protection Agency 1998, Abdalla and Lawton 2006). Livestock production produces a byproduct, manure, that contains nutrients such as nitrogen and phosphorous; but without proper management, these nutrients can degrade water sources (Aillery et al. 2005). To reduce the pollution from AFOs, the U.S. Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) promote the adoption of best management practices for manure as part of comprehensive nutrient management plans (CNMPs). While concentrated animal feeding operations (CAFOs) are required to adopt some practices, for other AFOs adoption is voluntary under the Federal Clean Water Act (U.S. Department of Agriculture and U.S. Environmental Protection Agency 1999). Therefore, a better understanding of the barriers to adoption will help policy makers and Extension staff more effectively promote nutrient management practices.

This study examines factors affecting adoption of two manure management practices: injecting manure and record keeping on the timing and location of manure applications. More specifically, we examine whether the nature of off-farm employment has differential effects on adoption of capital-intensive versus labor-intensive practices. We find that part-time employment of the farm operator, but not household off-farm income, positively affects adoption of manure injection.

The paper proceeds as follows: the next section reviews the literature on off-farm employment and technology adoption. We then develop hypotheses that guide our empirical strategy, described in the following section. We present our results and conclude with future research needs and implications for Extension efforts.

### *Adoption of New Technology and Off-Farm Work*

A voluminous literature, both theoretical and empirical, exists on adoption of agricultural practices

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[1] According to the EPA, an AFO is a lot or facility where the following conditions are met: animals are stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period and a ground cover of vegetation is sustained over less than 50 percent of the animal confinement area. CAFOs are regulated under the Clean Water Act and are operations with over 1,000 animal units (with one animal unit equivalent to a beef cow).

and technologies [recent reviews with an emphasis on adoption of conservation practices include Pannell et al. (2006), Prokopy et al. (2008), and Gedikoglu and McCann (2010)]. Profitability was one of the earliest factors studied and one that fairly consistently has a positive effect on adoption in the empirical literature (Griliches 1957, Koundouri, Nauges, and Tzouvelekas 2006, Rahm and Huffman 1994). Other factors, such as increased farm size (Feder, Just, and Zilberman 1985, Asafu-Adjaye 2008) and human capital/education (Abdulai and Huffman 2005, Chang and Boisvert 2005, Walton et al. 2008), tend to increase adoption. Factors that typically decrease adoption are increased age, credit constraints (Just and Zilberman 1998) and risk/uncertainty (Feder 1980, Feder and O'Mara 1982, Just and Zilberman 1998, Rahelizatovo and Gillespie 2004). Rogers (2003) includes perceptions about innovations—including compatibility with the existing system, which increases adoption—and discomfort and complexity, which decrease it.

Due to its increasing share in farm households' income, recent studies examined the role of off-farm income in the adoption of new technologies. Mishra et al. (2002) reported that the operator, spouse, or both worked off-farm in 71 percent of U.S. farm households in 2002. The share of off-farm income in total farm household income rose from roughly 50 percent in 1969 to 90 percent in 2007 (U.S. Department of Agriculture 2007). The contribution of women to farm household income through off-farm employment activities has also increased (Hallberg, Findeis, and Lass 1991, Tokle and Huffman 1991, Mishra et al. 2002). Ahearn and El-Osta (1993) showed that for many farm families, off-farm employment tends to be year-round, rather than a temporary source of income. This is consistent with evidence that farmers use off-farm employment to reduce the income variability of farm income (Huffman 1980, Barlett 1996, Mishra et al. 2002), in addition to increasing household income.

On the surface, the existing literature finds the effect of off-farm income on adoption is ambiguous, increasing adoption of some practices and decreasing adoption of others. Prokopy et al. (2008) found that labor availability, including both family and hired labor, tended to increase adoption of best management practices (BMPs). Off-farm employment would be expected to decrease the availability of labor and thus adoption. Cornejo, Hendricks and Mishra (2005) found that adoption of herbicide-tolerant soybeans is positively and significantly affected by farmers' off-farm income and indicate that adoption could be due to the time-saving nature of this technology. Similarly, in an analysis of farmer participation in the Conservation Reserve Program (CRP), a federal program that reduces farmed acres and thus operator labor requirements, Chang and Boisvert (2005) reported an increased probability of participation by farmers who have off-farm employment. Other federal conservation programs are focused on working lands and provide technical assistance and cost sharing and may actually increase labor and/or capital requirements. Hua, Zulauf, and Sohngen (2004) found a negative and significant relationship between off-farm employment and participation in a formal conservation program. The authors argued that farmers with off-farm employment have a high opportunity cost for the time that is required to participate in a conservation program, and that additional funds are required by farmers to participate in these cost-share programs.

The empirical results of these studies show that the off-farm income level of farmers impacts their decisions to adopt new technologies. The role of off-farm income in technology adoption is complex. On one hand, off-farm income sources increase farm families' financial resources, which may increase the likelihood of adoption, particularly for practices that require significant upfront investments. On the other hand, holding an off-farm job, whether seasonal or year-round, reduces the amount of time available to work on the farm, which may increase adoption of time-saving technologies and reduce adoption of time-intensive technologies. In addition, off-farm employment may imply that less importance is attached to the farming enterprise, which would reduce adoption of new technologies or practices. The objective of this paper is to improve our understanding of the impact of off-farm income and off-farm employment on adoption of new technologies by examining who earns the income, whether employment is seasonal or full-time, and how these factors interact with the characteristics of the technology.

## Conceptual Model

Off-farm income may be earned (wages or salaries) or unearned (retirement or dividends). According to the U.S. Department of Agriculture (2007), 72 percent of the total off-farm income was earned income. While both earned and unearned income may provide financial resources for the farm operation, only earned income—i.e., off-farm employment of the farm operator—would restrict the time available for on-farm activities. In the current paper, we include off-farm employment variables for both the farm operator and the spouse, to help explain the contradictory results of previous studies. Information on the employment of the operator is included separately since some studies in developing countries have found that household production decisions are contested, i.e., that the husband and wife may have different or even conflicting objectives (McPeak and Doss 2006). This implies that whoever earns the income affects how that money is spent, so operator employment and earnings should have more of an effect on farm decisions than employment and earnings of the spouse.

Based on the empirical evidence from previous studies, the impact of off-farm employment on technology adoption is related to the capital and labor availability of the farmers, as well as the characteristics of the practice being considered. Farmers with off-farm employment will have more financial resources available due to increased income, ceteris paribus, but will have less labor available due to time spent in off-farm activities. Specific technologies or practices can be classified with respect to their relative capital and labor intensities as described below. We hypothesize that farmers with off-farm employment are more likely to adopt relatively capital-intensive technologies but are less likely to adopt relatively labor-intensive technologies than farmers with no off-farm employment. We also hypothesize that the type of off-farm employment (seasonal versus full-time) will affect adoption. Those with full-time employment are expected to be less likely to have farming as their primary occupation.

Two practices that are expected to reduce environmental impacts of manure use are examined in this study: injecting manure and record keeping. Injecting manure into the soil minimizes nitrogen losses and odor problems (Prairie Agricultural Machinery Institute 1997), as well as phosphorous runoff. Nitrogen that volatilizes from surface application represents a loss of valuable nutrients to the farmer as well as contributing to air quality problems. The nitrogen loss during application can be minimized to as low as 1 percent with injection, whereas with sprinkler irrigation, nitrogen loss is typically 30 percent (Prairie Agricultural Machinery Institute 1997). While incorporating manure would also reduce these problems (Aillery et al. 2005) and would be appropriate for solid manure, we focused on injecting manure since it requires a large capital investment. There is little information on adoption rates in the literature. In the Chaudière region of Québec, which has high concentrations of livestock and has been the object of significant efforts to improve water quality, the adoption rate for injection of liquid manure was 45 percent (Ghazalian, Larue, and West 2009). The major drawback to injection is the cost, and it is also not appropriate for some cropping systems (Prairie Agricultural Machinery Institute 1997). The cost of typical equipment required for manure injecting systems, excluding the tractors, ranges from $200,000 to $400,000 or more, depending on the size of the hose and level of control technology (Erb 2011). Therefore, injecting manure is a capital-intensive technology.

Proper manure nutrient management aligns manure applications with crop needs to reduce negative environmental impacts. Record keeping regarding the timing and location of manure applications is one component of a comprehensive nutrient management plan (Aillery et al. 2005), so it is hard to evaluate the environmental benefits in isolation. Information on the prevalence of record keeping is also limited. Results from focus groups with farmers participating in a manure education program in Minnesota found adoption rates of 64 percent for keeping records on manure application amounts per field (Everett and Vickery 2005). For record keeping, some of the information should be recorded annually, such as soil tests, but other information, such as manure application records, should be kept more frequently (Iowa State University 2003). Hence, record keeping is a relatively labor-intensive practice.

## Empirical Model

For the empirical model, the adoption decision of the farmers can be represented in a random utility framework (Greene 2003). In this framework, the utility gained from adoption of a practice is compared to the utility from not adopting the practice.

Let $U_a$ represent the level of utility from adopting a practice and $U_b$ represent the level of utility from not adopting the practice. The adoption decision can be represented as:

(1) $y_i = 1$ (*farmer adopts the practice*) *if* $U_a > U_b$

(2) $y_i = 0$ (*farmer does not adopt the practice*) *if* $U_a \leq U_b$ .

The utility function $U$(.) is assumed to be a function of farmer socioeconomic characteristics (SC), off-farm employment of the operator and the spouse (OFE), farm characteristics (FC), perceptions about the practice (PPP), and general environmental attitudes (EA). The empirical specification includes a random factor ε, which has a normal distribution. The utility function $U$(.) can thus be represented as:

(3) $U$(SC, OFE, FC, PPP, EA, ε).

For the econometric model, a univariate probit model is used for each practice (Greene 2003). This model can be represented as:

(4) $$y_i = \mathbf{X}_i \boldsymbol{\beta}_i + \varepsilon_i,$$

$y_i = 1$ *if the practice is adopted,*

0 *otherwise,*

where $\mathbf{X}_i$ is the vector that includes the values for the variables that form the deterministic part of the utility function for the observation *i,* and $\boldsymbol{\beta}_i$ is the vector that includes the coefficients to be estimated. The probability of adopting the practice, conditional on the explanatory variables, can be represented as:

(5) $$P(y_i = 1 | \mathbf{X}_i) = G(\mathbf{X}_i \boldsymbol{\beta}_i)$$

where $G$(.) is the cumulative distribution function. In the case of the probit model, the standard normal distribution function is used for $G$(.) (Greene 2003). The marginal or partial effect of a continuous variable $x_j$ can be calculated as:

(6) $$\frac{\partial P(y = 1 | \mathbf{X}_i)}{\partial x_j} = \frac{\partial G(\mathbf{X}_i \boldsymbol{\beta}_i)}{\partial x_j} B_j .$$

$$\frac{\partial G(\mathbf{XB})}{\partial x_j}$$

is the probability density function, which is valued at the mean of the independent variables to measure the partial impact of an independent variable, $x_j$, on the probability of adopting a practice. For a discrete variable, $x_j$, such as a dummy variable, the partial effect can be calculated following Greene (2003) as:

$$G(B_0 + B_1 x_1 + \ldots + B_j + \ldots + B_k x_k)$$

$$- \; G(B_0 + B_1 x_1 + \ldots + B_k x_k).$$

In the first parenthesis, $x_j$ is equal to 1 and in the second parenthesis $x_j$ is equal to 0.

## Data

A mail survey of 3,014 livestock farmers was conducted in Iowa and Missouri in the spring of 2006. Before random sampling, farmers were stratified by farm sales and by type of livestock. Farmers with farm sales of less than $10,000 were not sampled. This eliminates most retirement or lifestyle farmers (Hoppe and Banker 2006). The survey was designed and conducted following the methodology of Dillman (2000). A pretest was conducted and the survey was modified in response to feedback received. A cover letter and survey were sent, followed by a postcard reminder and a second cover letter and survey. Respondents who chose to write their name and address on a card were put in a random drawing for a $100 gift certificate to a major retailer. The effective response rate for the survey was 37.4 percent.

For the regression analysis, CAFOs were excluded from the data set to focus on factors that affect voluntary adoption. Respondents with pasture-only operations (e.g., cow-calf operations), and farmers with no land, were also excluded, since the practices related to land application of accumulated manure. Finally, five farmers who answered the same number for all perceptions for all practices are also removed from the data set, as their answers were not credible. These five farmers answered 3 (neutral) to all perceptions for all practices.

The survey contained Likert scale responses on a scale of 1 to 5, with 1 labeled as strongly disagree, 3 as neither agree nor disagree, and 5 as strongly agree. These numerical responses were converted into dummy variables, similar to the approach taken by Wooldridge (2006) for credit ratings. Responses 1 and 2 were combined and converted into one disagree dummy that served as the base, response 3 was a second dummy, and 4 and 5 (agree) were also combined. Response 3 was not combined with other responses in order to more directly compare agree and disagree responses. Respondents who chose response 3, the neutral choice, might have been those who did not have knowledge or opinions about the topic (Ryan and Garland 1999).

Most of the empirical studies focus on either adoption of an individual practice within a multicomponent technology package or adoption of the package as a whole (Khanna 2001, Dorfman 1996). Treating adoption of individual practices within a package as independent ignores the correlation among the adoption of interrelated practices within a package (Khanna 2001, Wozniak 1984) and results in inefficient estimates (Khanna 2001). Multinomial or bivariate probit is appropriate in that case. In the context of the current study, a bivariate probit model was tried, but the Wald test for the null hypothesis that injecting manure and record keeping are not correlated could not be rejected at the 10 percent significance level (the p-value was 0.33). Hence, the data did not provide statistical evidence to use bivariate probit (Wooldridge 2006, Cameron and Trivedi 2005).

An additional empirical concern is endogeneity of the off-farm employment decision. Some authors note that conservation decisions may be influenced by off-farm employment decisions. Phimister and Roberts (2006) found that the off-farm employment decision and decisions about the intensity of agricultural input use are made simultaneously. Chang and Boisvert (2005) concluded that the decision to work off-farm and the decision to participate in the Conservation Reserve Program (CRP) were not independent, but either joint or sequential. If sequential, their analysis suggested the employment decision was made prior to the CRP participation decision. The choice to put land into the CRP represents a fundamental change in the farm's production system by taking land out of production. The intensity of agricultural input use impacts the farm output, hence the farm income. The adoption decisions we consider in this paper are less drastic in that they do not fundamentally change the farming system or the farm income.

We tested for endogeneity of off-farm work using the Hausman test for endogeneity (Wooldridge 2006, Cameron and Trivedi 2005). The Wald test for the null hypothesis that off-farm work is exogenous could not be rejected at the 10 percent significance level for both injecting manure and record keeping (Wooldridge 2006, Cameron and Trivedi 2005). Hence, the data did not provide evidence to justify use of an instrumental variable probit or a simultaneous equation model.

Similar to off-farm work, endogeneity of attitudes and perceptions has been tested using the Hausman test for endogeneity (Wooldridge 2006, Cameron and Trivedi 2005). The Wald test for the null hypothesis that attitudes and perceptions are exogenous could not be rejected at the 10 percent significance level for both injecting manure and record keeping, when tested jointly (Wooldridge 2006, Cameron and Trivedi 2005). Hence, the data did not provide evidence to justify use of an instrumental variable probit, when we controlled for all the attitude and perception variables. For this reason, univariate probit regression has been used.

## Results and Discussion

Table 1 compares the percentage of the farmers in each farm sales category for the population sampled (livestock farms in Iowa and Missouri with more than $10,000 in sales) and the survey data. Relative to the sample population, proportionately more survey responses were received for farms selling less than $250,000. This discrepancy may be explained by the fact that CAFOs, which are larger operations, were eliminated from the dataset. While direct age comparisons between the data and the population are not possible, given the sample stratification and the fact

**Table 1. Comparison of Key Statistics**

| Variable | Data | Population* |
|---|---|---|
| Farm Sales | | |
| $10,000-$99,999 | 25% | 17% |
| $100,000-$249,999 | 38% | 36% |
| $250,000-$499,999 | 23% | 28% |
| $500,000+ | 14% | 19% |

* Population is the combined livestock farms in Iowa and Missouri used for sampling (USDA/NASS).

that only livestock producers with more than $10,000 in sales were sampled, the respondents' average age seems broadly representative of farmers in Missouri and Iowa. The average age for our sample was 50 years old, while the average age for all farmers in Iowa and Missouri was 56 years and 57 years old, respectively, according to the 2007 U.S. Census. However, according to the demographics publication from the U.S. Census, operators of larger farms are usually younger; and thus by eliminating farms with less than $10,000 in sales, we also disproportionately eliminated older farmers.

Summary statistics are presented in Table 2. Forty-one percent of the survey respondents had a high school degree (the base category for the regression analysis). Seventy-five percent of respondents had household off-farm income. About 14 percent of the farm operators had seasonal off-farm employment, while 23 percent had year-round off-farm work. Fifty-eight percent of the survey respondents were from Iowa and the rest were from Missouri. Thirty-eight percent of the respondents had farm sales (including both crop and livestock sales) between $100,000 and $249,999 (the base category for the regression analysis). Only 15 percent of the farmers had an Environmental Quality Incentives Program (EQIP) contract through the Natural Resources Conservation Service. Adoption rates were 19 percent for injecting manure and 26 percent for record keeping. Compared to record keeping, injection was perceived as being more profitable, having more of an impact on water quality, being less time consuming, and being less complicated.

For each practice, two regressions were developed: one that corresponds to the typical treatment in the literature—i.e., without variables on off-farm employment of the farm operator and the spouse, only total off-farm income—and another that only includes dummy variables for seasonal and year-round off-farm employment for the farm operator and the spouse, with no off-farm employment serving as the base category (Table 3). Total off-farm income includes employment income of both the operator and the spouse and also any unearned income. The pseudo $R^2$ for the off-farm employment model is 0.66 for injecting manure and 0.29 for record keeping. The $R^2$ for injecting manure with off-farm work variables is higher than the regression with off-farm income variables. However, the opposite is true for record keeping, although the difference is smaller. Our data show evidence that off-farm work variables may be useful additions to adoption studies.

Multicollinearity for the regression variables was checked using the variance inflation factor (VIF). The rule of thumb is to further investigate variables for which VIF is greater than 10 (Chen et al. 2003). The only variables meeting this threshold were age and age squared (the data are available upon request). Since age squared is derived directly from age, this result is expected. Hence, there is no evidence of multicollinearity in the regressions. Heteroskedasticity robust standard errors are used in the analysis. The p-value of the Wald Chi-square test statistics for overall significance of the regressions was 0.000, which shows that the probit regressions were significant overall.

**Table 2. Summary Statistics**

| Variable | N | Mean | Std. Dev. | Range |
|---|---|---|---|---|
| Farmer Characteristics | | | | |
| Age (in years) | 417 | 50 | 10 | 26-84 |
| Education (highest level achieved) | | | | |
| *Less than High School* | 417 | .11 | .31 | 0-1 |
| *High School* | 417 | .41 | .49 | 0-1 |
| *Some College or Vocational School* | 417 | .28 | .45 | 0-1 |
| *Bachelor Degree* | 417 | .20 | .39 | 0-1 |
| Off-Farm Income (total, earned, and unearned) | | | | |
| *None* | 417 | .25 | .43 | 0-1 |
| *$0-$9,999* | 417 | .15 | .35 | 0-1 |
| *$10,000-$24,999* | 417 | .16 | .37 | 0-1 |
| *$25,000-$49,999* | 417 | .30 | .46 | 0-1 |
| *$50,000-$99,999* | 417 | .12 | .32 | 0-1 |
| *$100,000+* | 417 | .02 | .14 | 0-1 |
| Off-Farm Employment (categorical) | | | | |
| *Operator Seasonal* | 417 | .14 | .38 | 0-1 |
| *Operator Year-Round* | 417 | .23 | .41 | 0-1 |
| *Spouse Seasonal* | 417 | .07 | .25 | 0-1 |
| *Spouse Year-Round* | 417 | .51 | .49 | 0-1 |
| Hire Nonfamily Labor | 417 | .47 | .50 | 0-1 |
| Farm Characteristics | | | | |
| Iowa | 417 | .58 | .49 | 0-1 |
| Missouri | 417 | .42 | .50 | 0-1 |
| Farm Sales (crop and livestock) | | | | |
| *$10,000-$99,999* | 417 | .25 | .43 | 0-1 |
| *$100,000-$249,999* | 417 | .38 | .49 | 0-1 |
| *$250,000-$499,999* | 417 | .23 | .41 | 0-1 |
| *$500,000+* | 417 | .14 | .34 | 0-1 |
| Total Animal Units (AU) | 417 | 303 | 232 | 5-992 |
| Livestock Species (predominant by AU) | | | | |
| *Dairy* | 417 | .28 | .45 | 0-1 |
| *Beef Cow/Calf* | 417 | .24 | .43 | 0-1 |
| *Beef Cattle* | 417 | .14 | .36 | 0-1 |
| *Swine* | 417 | .20 | .39 | 0-1 |
| *Poultry* | 417 | .04 | .20 | 0-1 |
| *Turkey* | 417 | .08 | .27 | 0-1 |
| *Other* | 417 | .02 | .13 | 0-1 |
| Manure Handling System (categorical) | | | | |
| *Solid Handling* | 417 | .64 | .48 | 0-1 |
| *Liquid Handling* | 417 | .08 | .26 | 0-1 |
| *Solid and Liquid Handling* | 417 | .28 | .45 | 0-1 |
| Environmental Quality Incentives Program (Currently Participate in this USDA Program) | 417 | .15 | .36 | 0-1 |

(continued)

**Table 2. Summary Statistics (continued)**

| Variable | N | Mean | Std. Dev. | Range |
|---|---|---|---|---|
| *Perceptions about the Practices (1= strongly disagree, 5=strongly agree)* | | | | |
| Inject Manure | | | | |
| Profitable<br>*"This is a profitable practice; it improves my bottom line"* | 411 | 3.50 | 1.23 | 1-5 |
| Improves Water Quality<br>*"This practice improves water quality"* | 411 | 3.76 | 1.01 | 1-5 |
| Time-Consuming<br>*"This practice is time-consuming"* | 411 | 3.34 | 1.17 | 1-5 |
| Complicated<br>*"This practice is complicated"* | 411 | 2.88 | 1.16 | 1-5 |
| Record Keeping | | | | |
| Profitable | 417 | 3.19 | 1.28 | 1-5 |
| Improves Water Quality | 417 | 3.43 | 1.12 | 1-5 |
| Time-Consuming | 417 | 3.61 | 1.14 | 1-5 |
| Complicated | 417 | 3.10 | 1.14 | 1-5 |
| General Attitudes | | | | |
| Smell bothers us<br>*"The smell of manure bothers me or my family"* | 417 | 2.67 | 1.06 | 1-5 |
| Dependent Variables<br>("Do you perform this practice?") | | | | |
| Injecting Manure | 411 | .19 | .39 | 0-1 |
| *"Inject manure into the soil during application"* | | | | |
| Record Keeping | 417 | .26 | .49 | 0-1 |
| *"Keep detailed records on what day, how much, and to what field manure was applied"* | | | | |

### *Farmer Characteristics*

While the technology adoption literature finds that increasing age is often negatively associated with adoption, the current study found a positive relationship between age and adoption of injecting manure. This could reflect the impact of the experience of the farmers or a wealth effect. More education is generally associated with higher adoption rates (Wozniak 1984, Chang and Boisvert 2005, Barham et al. 2004). In the current study, farmers with less than a high school education are less likely to inject manure than those with a high school education. For record keeping, farmers with some college or a vocational school degree are more likely to adopt than farmers with a high school degree.

### *Off-Farm Income*

Off-farm income categories were not significant for injecting manure or record keeping. It was expected that operations with higher off-farm income would be more likely to adopt injecting manure, as additional income can be used to cover the costs of this capital-intensive practice. This result might indicate that farm households do not necessarily use their off-farm income for farm

**Table 3. Results for Univariate Probit Regressions**

| Variable | Injecting Manure (Off-Farm Emp.) | | Injecting Manure (Off-Farm Inc.) | | Record Keeping (Off-Farm Emp.) | | Record Keeping (Off-Farm Inc.) | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | dy/dx | Coefficient | dy/dx | Coefficient | dy/dx | Coefficient | dy/dx |
| Farmer Characteristics | | | | | | | | |
| Age | 0.16* | 0.000 | 0.06 | 0.000 | -0.03 | -0.007 | -0.01 | -0.002 |
| Age^2 | 0.00* | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| Education *(Base=High School)* | | | | | | | | |
| *Less than High School* | -2.32*** | -0.001 | -1.99*** | -0.004 | -0.01 | -0.002 | -0.04 | -0.009 |
| *Some College or Vocational School* | 0.07 | 0.000 | -0.13 | 0.000 | 0.42** | 0.124 | 0.33* | 0.092 |
| *Bachelor & Grad Degree* | 0.52 | 0.001 | 0.29 | 0.003 | -0.01 | -0.002 | 0.03 | 0.008 |
| Off-Farm Income *(Base=$10,000-$24,999)* | | | | | | | | |
| *None* | | | -0.45 | -0.001 | | | 0.18 | 0.040 |
| *$0-$9,999* | | | 0.28 | 0.006 | | | 0.35 | 0.009 |
| *$25,000-$49,999* | | | -0.19 | 0.000 | | | 0.06 | 0.015 |
| *$50,000-$99,999* | | | -0.15 | -0.002 | | | -0.01 | -0.010 |
| *$100,000+* | | | -0.31 | -0.002 | | | -0.76 | -0.133 |
| Off-Farm Employment *(Base=No)* *Operator Seasonal* | 0.36* | 0.002 | | | 0.07 | 0.020 | | |
| *Operator Year-Round* | -0.37 | 0.000 | | | -0.17 | -0.046 | | |
| *Spouse Seasonal* | -0.09 | 0.000 | | | -0.01 | -0.002 | | |
| *Spouse Year-Round* | 0.50 | 0.000 | | | -0.14 | -0.039 | | |
| Hire Nonfamily Labor | 0.50* | 0.000 | 0.34 | 0.000 | 0.17 | 0.048 | 0.21 | 0.051 |
| Farm Characteristics | | | | | | | | |
| Iowa (Base=Missouri) | 2.33*** | 0.006 | 2.01*** | 0.022 | 0.09 | 0.025 | 0.40** | 0.103 |
| Farm Sales *(Base=$100,000-$249,999)* | | | | | | | | |
| *$10,000-$99,999* | 0.12 | 0.000 | 0.04 | 0.000 | 0.31 | 0.090 | 0.04 | 0.010 |
| *$250,000-$499,999* | -0.23 | 0.000 | -0.01 | 0.000 | 0.06 | 0.017 | -0.04 | -0.013 |
| *$500,000+* | 0.50 | 0.001 | 0.87** | 0.022 | -0.02 | -0.004 | -0.16 | -0.039 |
| Total Animal Units | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 | 0.00 | 0.000 |
| Manure Handling *(Base=Liquid Handling)* | | | | | | | | |
| *Solid Handling* | -3.84*** | -0.134 | -3.19*** | -0.190 | -1.43*** | -0.433 | -1.43*** | -0.429 |
| *Solid and Liquid Handling* | -1.92*** | -0.002 | -1.79*** | -0.010 | -1.28*** | -0.267 | -1.12*** | -0.234 |

(continued)

**Table 3. Results for Univariate Probit Regressions (continued)**

| Variable | Injecting Manure (Off-Farm Emp.) | | Injecting Manure (Off-Farm Inc.) | | Record Keeping (Off-Farm Emp.) | | Record Keeping (Off-Farm Inc.) | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | dy/dx | Coefficient | dy/dx | Coefficient | dy/dx | Coefficient | dy/dx |
| Livestock Species (Base=Swine) | | | | | | | | |
| *Dairy* | -0.50 | 0.000 | -0.45 | -0.002 | -0.09 | -0.024 | -0.22 | -0.053 |
| *Beef Cow* | 0.06 | 0.000 | -0.35 | -0.001 | -0.22 | -0.056 | -0.32 | -0.067 |
| *Beef Cattle* | 0.10 | 0.000 | -0.43 | -0.004 | -0.50 | -0.115 | -0.39 | -0.085 |
| *Poultry* | -0.14 | 0.000 | -0.59 | -0.001 | 0.67 | 0.225 | 0.78* | 0.278 |
| *Turkey* | 0.53 | 0.001 | 0.31 | 0.001 | 0.60* | 0.196 | 0.75** | 0.258 |
| *Other* [a] | | | | | 0.48 | 0.154 | 0.54 | 0.182 |
| Environmental Quality Incentives Program | -1.21** | -0.001 | -1.11** | -0.009 | 0.06 | 0.017 | 0.24 | 0.062 |
| Perceptions about the Practices | | | | | | | | |
| Profitable *(Base=Disagree)* [b] | | | | | | | | |
| *Agree* | 1.88*** | 0.007 | 1.64*** | 0.350 | 1.17*** | 0.339 | 1.08*** | 0.320 |
| *Neutral* | 0.29 | 0.000 | 0.41 | 0.002 | 0.51* | 0.147 | 0.42* | 0.106 |
| Improves Water Quality | | | | | | | | |
| *Agree* | -0.53 | -0.002 | -0.37 | -0.002 | -0.15 | -0.041 | -0.09 | -0.027 |
| *Neutral* | -1.57** | -0.244 | -1.51** | 0.532 | -0.41* | -0.106 | -0.43* | -0.099 |
| Time Consuming | | | | | | | | |
| *Agree* | 0.32 | 0.000 | -0.13 | -0.008 | -0.30 | -0.081 | -0.42** | -0.086 |
| *Neutral* [c] | -0.01 | 0.000 | -0.42 | -0.004 | | | | |
| Complicated | | | | | | | | |
| *Agree* | -1.46*** | -0.001 | -1.22*** | -0.230 | -0.27 | -0.071 | -0.37* | -0.090 |
| *Neutral* | -0.80* | -0.001 | -0.74** | -0.110 | -0.29 | -0.078 | -0.37** | -0.099 |
| Attitudes about the Environment | | | | | | | | |
| "Smell bothers us" | | | | | | | | |
| *Agree* | -1.08*** | 0.000 | -0.63** | -0.100 | -0.20 | -0.051 | -0.19 | -0.007 |
| *Neutral* | -0.32 | 0.000 | -0.29 | 0.000 | -0.08 | -0.020 | -0.09 | -0.008 |
| N | 411 | | 482 | | 417 | | 487 | |
| Pseudo R-squared | 0.66 | | 0.62 | | 0.29 | | 0.30 | |
| Wald Chi-square | 298 | | 246 | | 115 | | 141 | |
| p-value for Wald chi-square | 0.000 | | 0.000 | | 0.000 | | 0.000 | |

[a] Dropped from the regression due to no variation for Injecting Manure.
[b] Base category is Disagree for the all the categorical variables below.
[c] Dropped from the regression due to no variation for Record Keeping (did not adopt).
Note: Three asterisks (***) indicate significance at 1 percent level, two asterisks (**) at the 5 percent level, and one asterisk (*) at the 10 percent level.

production activities. This income may be saved or used for household expenses. The type of income, earned versus unearned, may also be important, but our data only includes total off-farm income.

### *Off-Farm Employment*

In the current study, we find that if the farm operator has seasonal off-farm work, the farmer is more likely to adopt injecting manure than a farmer who has no off-farm work. There is no effect of operator's off-farm employment on record keeping. Spouse's off-farm employment does not significantly affect the decision to inject manure or adopt record keeping. It was expected that the time involved with off-farm employment would decrease adoption of more labor-intensive practices such as record keeping and that having seasonal off-farm employment would provide the extra income that is necessary to adopt injecting manure. This latter effect may not show up in the total off-farm income variable since it includes earnings of both the operator and the spouse and, as we mentioned, decision making may be contested within the household (McPeak and Doss 2006). Hiring nonfamily labor had a positive effect on adoption of injecting manure, in line with the general conservation practice adoption literature (Prokopy et al. 2008).

Comparison of the regression results with our hypotheses shows support for the case of injecting manure; the results provide evidence that adoption of a capital-intensive practice is positively impacted by the off-farm employment of the farmer. This result is consistent with previous studies that found a positive relationship between off-farm income and adoption of a new technology. We were not able to find studies examining off-farm employment impacts on adoption. However, the regression results do not provide evidence for the hypothesis that adoption of a relatively labor-intensive practice, such as record keeping, is negatively impacted by the off-farm employment of the farmer. The results also do not support the results of the previous studies that found a negative relationship between adoption of a new technology and off-farm work. It may be that more highly labor-intensive practices, and ones where timeliness is important, need to be examined to further test this hypothesis.

### *Farm Characteristics*

Farmers in Iowa were more likely to adopt injecting manure than farmers in Missouri, which may relate to the more cropping-intensive nature of farming systems in that state, which increases the demand for nutrients (Hoag and Roka 1995). This is bolstered by the finding that farmers with EQIP contracts are less likely to adopt injection, which means it is not being adopted primarily for its environmental impacts. Iowa farmers were more likely to adopt record keeping only in the off-farm income model. Farm sales did not significantly impact injecting manure and record keeping in the off-farm employment models, but the largest farms were more likely to adopt injecting manure in the off-farm income model. Also, there was no effect of animal units on adoption of either practice. Turkey operations were more likely to adopt record keeping than swine operations in the off-farm employment model, and this was true for both poultry and turkey operations in the off-farm income model. This may be explained by our finding that these operations tended to have fewer cropped acres on which to apply the manure. Poultry and turkey operations are also more likely to operate under fixed contract agreements that require them to maintain detailed records.

Type of manure handling system is significant for both injecting manure and record keeping in both models. Farmers with only solid manure handling systems, or both liquid and solid systems, are less likely to adopt injecting manure than the ones with only liquid manure handling systems. As the farmers need liquid manure to inject it, this result is consistent with expectations. Farmers with solid or combination manure handling systems are also less likely to adopt record keeping than farmers with only liquid manure handling systems. This may be explained by the fact that manure storage capacity and the potential for a spill are more of an issue for lagoons. In the event of a discharge to waterways, detailed records may be useful for interactions with regulatory agencies (Lory 2011).

### *Perceptions about the Practices*

Respondents were asked to indicate their agreement with four statements on a scale of 1 (strongly disagree) to 5 (strongly agree). They included:

"This is a profitable practice, it improves my bottom line"; "This practice improves water quality"; "This practice is time consuming"; and "This practice is complicated." There is a statistically significant and positive relationship between perceived profitability of both practices and their adoption, in line with the literature. Agreeing that the practices improved water quality did not affect adoption compared to those who disagreed. Interestingly, though, having a neutral perception decreased the likelihood of adoption of both practices in both models. As we indicated, a neutral response may indicate a lack of knowledge, which may indicate a lack of interest in the issue of water quality more generally. Our hypothesis that off-farm employment would decrease the time available for record keeping, and thus decrease adoption, was not supported. However, under the off-farm income model, farmers who agreed that record keeping was time-consuming were less likely to adopt. Thus, the perception of the labor intensity of this practice may inhibit adoption by some farmers. Farmers that agree or have a neutral perception that injecting manure is complicated are less likely to adopt than farmers who disagree. This is also true for record keeping with the off-farm income model. This result indicates that the perception of being complicated may be a significant barrier to adoption for both practices. There may thus be a role for Extension in reducing the perceived complexity of these practices.

Farmers who agreed with the statement, "The smell of manure bothers me or my family," are less likely to inject manure than farmers who disagreed with the statement. According to Rogers (2003), people want to avoid discomfort. While injection reduces odor and thus would be expected to be positively correlated with this statement, farmers themselves may spend more time injecting the manure than with other systems, particularly if they do not have hired labor. It is further evidence that injection is not being adopted for its environmental impacts in this region.

### *Marginal Effects*

Marginal effects were also calculated to determine which factors had a large impact on adoption, in addition to being statistically significant. Overall, the manure handling system, and perceptions about profitability, are the most important factors that impact adoption. While the explanatory power of the models of adoption of record keeping were lower than that for injection, the variables that were significant tended to have a large effect. Given the nature of record keeping, it is understandable that having some college education would have a large impact on adoption and that perceptions of it being time-consuming and complicated would be important barriers. The effect of poultry and turkey operations compared to swine operations on the adoption of record keeping was also large. While statistically significant for injecting manure, the off-farm employment variable was not very important.

## Conclusion

Previous studies provide conflicting evidence on the role of off-farm income in farmers' adoption decisions. This paper sought to clarify the role of off-farm income by considering who earns the off-farm income, the nature of the employment, and the nature of the potential practice being considered (capital-intensive versus labor-intensive). The current study provided evidence that off-farm employment of the operator is a better predictor of impacts on adoption of new technologies and practices than the standard off-farm income variable. Our empirical results provide evidence that adoption of a capital-intensive technology is positively impacted by the operator's off-farm employment. However, the results did not support the hypotheses for a relatively labor-intensive practice. Further research is required that incorporates a highly time- or labor-intensive technology. A future study that incorporates the specific sources of off-farm income (earned versus unearned, spouse versus operator), as well as more specific questions on the type of off-farm employment, such as when it occurs, into the analyses will help to understand the impact of off-farm income and employment on technology adoption. Questions regarding the perceived importance of the farming enterprise versus off-farm work, such as the primary occupation of the farm operator, might also be useful. While more research is needed, the fact that so many farmers do have part-time and full-time jobs implies that Extension educators need to take account of this fact when they determine when to offer programs and what the mode of delivery should be.

The conventional wisdom is that farmers with positive attitudes about conservation would adopt environmental practices. However, the current study provided evidence that the perceived water quality impact of the practices had no effect on adoption. Hence, Extension programs focusing on the specific benefits of the practices, including profitability in some cases, should lead to higher adoption rates. Education programs that make practices seem less complicated and less time-consuming would also be expected to lead to higher adoption rates, based on this research. Research on new technologies and practices should take account of these factors as well so that more user-friendly practices are developed.

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