Farming and the Internet: Reasons for Non-Use

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Rural broadband infrastructure and service has received a significant amount of funding through the American Recovery and Reinvestment Act of 2009. These funds should increase broadband availability, but will broadband be used in rural areas and in particular by farmers? This paper uses Agricultural Resource Management Survey data to investigate why the majority of U.S. farmers choose *not* to use the Internet in their farm business. Although frequently cited by policymakers, concerns about inadequate Internet service or security actually account for a small percentage of responses. This research identifies targeted educational programs that focus on alleviating perceived barriers to Internet use.

Key Words: ARMS, farming, Internet, multinomial logit, non-use

The Internet has woven its way into nearly every aspect of American life: people use it for communication, entertainment, education, and commerce opportunities (Horrigan and Rainie 2006). In 2005, approximately 73 percent of Americans used the Internet from some location (Madden 2006). To increase Internet availability, the federal government is providing $7.2 billion through the American Recovery and Reinvestment Act (ARRA) of 2009 to raise levels of Internet broadband[1] infrastructure throughout the United States, especially in rural areas. While this increased availability will benefit both individuals and businesses, many industrial sectors have already begun to take advantage of the "information revolution" provided by the Internet. Businesses are using the Internet to improve profitability by lowering costs and increasing revenues.

The farming industry, in particular, has realized several potential benefits of the Internet. For example, the Internet provides access to timely information (such as weather forecasts or market prices). Farms can also reduce costs by buying in-bulk inputs online or purchasing inputs that are not available locally. New markets are made available to farmers through individual farm websites. And, some farmers are selling their products online.

Yet, not all U.S. farms are taking advantage of the business opportunities that the Internet presents. According to the 2005 Agricultural Resource Management Survey (ARMS) data, only 30 percent of U.S. farmers indicated that they use the Internet as part of their farm business. Hence, most farmers still do *not* use the Internet in their farm business. The objective of this study is to identify key farm and household characteristics that influence a farmer's decision *not* to use the Internet on the farm.

The reasons for non-use can be quite varied, including unfamiliarity with the technology, the lack of a computer, no perceived need, and concerns about Internet connections, security, or cost. Several of these reasons have been explicitly noted by individuals and groups concerned with agriculture, including researchers, policymakers, and extension programs. Henderson, Dooley, and Akridge (2004) indicate that nearly half of agri-

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[1] Broadband (or high-speed) access is defined by the Federal Communications Commission as 200 kilobytes per second (Kbps) of data throughput, or roughly four times the speed of a dial-up modem (typically 56 Kbps). It is generally accepted as a superior type of Internet service when compared to dial-up.

business firm managers feel that farmers' security issues were a barrier to e-commerce adoption. Similarly, McFarlane, Chembezi, and Befecadu (2003) find that 41 percent of agribusiness firms with websites believe that farmers have privacy concerns with purchasing over the Internet. Smith et al. (2004) recognize that Internet use is, for the most part, contingent upon owning a computer, and separately estimate models on computer and Internet adoption for Great Plains farmers.

Another potential reason for non-use by farmers is poor Internet service. Whitacre and Mills (2007) find that the presence of wired broadband infrastructure in rural areas was well behind that for urban areas over the period 2000–2003. Typically acknowledged as lagging in rural areas, broadband infrastructure has seen funding increases from the rural development portion of the Farm Bill in each version since 1996. In addition, two distinct broadband infrastructure programs are included in the ARRA—one headed by the Rural Utility Service (with $2.5 billion in funding), and one headed by the National Telecommunications and Information Administration (with $4.7 billion).

Although some of these reasons for non-use have been cited by farm Internet studies or addressed by policy programs, the rationale behind a farmer choosing a particular reason is largely unexplored. Do certain household or farm factors lead to specific reasons for non-use? If so, what policy or program prescriptions should be rendered to promote further use of the Internet on the farm? In particular, does the money spent under the ARRA programs address the most important reason why most farmers are not using this technology?

Answering these questions is a unique contribution of this study because the previous literature focused on characteristics that impact a farmer's decision to adopt the Internet (Mishra and Williams 2006, Mishra and Park 2005, Smith et al. 2004, Rolfe, Gregor, and Menzies 2003, Gloy and Akridge 2000). Little attention has been given to identifying the underlying factors affecting a particular reason for *not* making use of this technology.

To date, policy and program suggestions for increasing future farmer access rates have been quite generic. For example, Mishra and Park (2005) state that computer knowledge among farmers must be enhanced. Still, extension educators have long recognized the importance of educating their farm clientele on how to use computers (Findley et al. 1993), particularly when it comes to taking advantage of the Internet (Hall et al. 2003). A firm understanding of the rationale behind non-use decisions will provide insights into the perceived barriers of gaining access to the Internet and using it in the farm business.

Three distinct reasons why farmers do not use the Internet in the farm business have dominated policy and academic discussions: no computer, inadequate Internet service, and Internet security concerns. The 2005 ARMS data provide the necessary information to evaluate these reasons for non-use by U.S. farm households. This study uses a multinomial logit model to identify key characteristics of farm households that do not use the Internet in their farm business. From these results, potential policies and educational programs aimed at increasing the use of the Internet on the farm are discussed.

Many intuitive results are found, including high likelihoods for older operators and lower income farm households to state that they do not use the Internet in their farm business because they do not have a computer. An unexpected result is that living in a more rural area is not a significant factor for farms selecting inadequate Internet service as a reason for non-use. This result does not support the popular belief that farmers are not using the Internet in rural America due to poor Internet service. Potentially, this perceived barrier to using the Internet on the farm has already been negated by an ever-expanding broadband infrastructure in rural America. New policies and educational programs may need to address different perceived barriers to using the Internet. Thus, while the rural broadband provisions of the ARRA may benefit rural individuals and some small businesses, this study does not suggest that they will dramatically improve the use of the Internet on farm businesses.

Several suggestions for specific programs follow from the results. First, farm households with a large time commitment to the farm need to have their Internet security concerns alleviated. Second, general information on the benefits of Internet use should be provided to leisure farmers (those with smaller time commitments). Third, farmers without a computer and those who do not perceive a need for the Internet in their farm business need to be educated on the future USDA

farm programs that will require online forms. These prescriptions focus on some of the key characteristics that significantly impact farmers' decisions on whether or not to use the Internet on the farm. All of the key characteristics used in this study relate to the literature on Internet adoption.

Literature Review

Most academic studies on farm Internet access can be divided into two distinct categories: those focusing on the factors affecting its adoption and those focusing on ways farm businesses use the technology. Table 1 summarizes the results of several studies dating back to 2000. Gloy and Akridge (2000) developed a similar summary for farm Internet adoption studies prior to 2000.

Farm Internet Adoption Studies

The typical adoption study is set up as a discrete choice model, where the decision maker faces a simple yes/no choice on whether or not to adopt the Internet. This decision is based on the utility that the household would receive from adopting the Internet versus the utility from not adopting it. Rogers (1962) was among the first to hypothesize that the adoption decision could be a function of individual characteristics, such as education and income.

For farm households, the Internet adoption decision is usually modeled based on any number of farm and individual characteristics. Most studies looking at Internet adoption at the farm household level consider farm size, measures of farm/non-farm income, education, and age as independent variables, along with other factors of interest. In a recent study using 2004 data, Mishra and Williams (2006) examine the propensity for a farm household to adopt the Internet using a similar subset of factors. Their results show that education, farm size, and regional location positively impact the likelihood of adopting the Internet, while age exhibits a quadratic effect, showing that older operators are less likely to adopt the Internet. Gloy and Akridge (2000) find similar results for their sample of commercial U.S. farmers.

Smith et al. (2004) use a similar model to study computer and Internet access by Great Plains farmers. When modeling only computer adoption, they find significant results for age (including a quadratic effect), off-farm employment, and education. However, when modeling whether the Internet is used for the farm business, none of these variables are significant; instead, only formal and informal computer education display an impact.

Website adoption by a business is another caveat to this literature. Ernst and Tucker (2001) find that the presence of a male business owner and his level of optimism about information technology (IT) serve as significant predictors for IT and website adoption among fruit and vegetable growers in Ohio. Adopters are also less likely to be located near smaller towns (as opposed to larger ones). This fact indicates that rurality may be an important predictor of adoption. Even rural non-farm households have historically had a lower likelihood of adopting the Internet (McConnaughey and Lader 1998, Horrigan 2006).

Farm Internet Use Studies

Several studies have examined the adoption decision further by considering how farmers have incorporated the Internet into their lives and farm businesses. Rolfe, Gregor, and Menzies (2003) attempt to determine whether farmers adopt the Internet (i) for cost reduction purposes, or (ii) for increases in productivity. Their results give little evidence that farmers are able to identify either cost or time savings from using the Internet. Rather, they show that some value comes from adding to levels of productivity, including increased availability of technical information.

Smith et al. (2004) find that most farmers in the Great Plains region are using the Internet as a source of information. Ninety-two percent of the respondents to their survey retrieve more than one type of information (such as financial, weather, or agricultural policy), and 50 percent collect at least four types of information from the Internet. Mishra and Park (2005) estimate the number of specific types of applications used by a farm operator as count data. Using Poisson and negative binomial models, they find several significant variables that lead to more applications being used. In particular, the number of applications is positively influenced by higher levels of education, higher farm sales, higher levels of farm production diversification, and larger amounts of off-farm investments. Interestingly, the amount of

Table 1. Farm Internet Adoption Studies from 2000 to Present

Study	Dependent Variable	Significant Results
Mishra and Williams (2006)	*Internet adoption (general)*	Age (+) Age^2 (-) Education (+) Off-farm income (+) Presence of a spouse (+) Regional location (+) Farm size (+)
Mishra and Park (2005)	*Number of Internet applications used*	Education (+) Farm size (+) Farm diversification (+) Off-farm income (-) Off-farm investments (+) Regional location (+)
Smith et al. (2004)	*Computer adoption (general)*	Age (+) Age ^2 (-) Education (+) Off-farm work (+)
	Internet adoption (farm business)	Computer education—college (+) Computer education—friends / family (+)
Rolfe, Gregor, and Menzies (2003)	*Perceived advantage in Internet use*	Value of weather information (-) Value of technical information (+) Value of electronic banking (+)
Ernst and Tucker (2001)	*IT adoption (Internet, website presence)*	Gender—Male (+) Economic optimism (+) Proximity to small town (-)
Gloy and Akridge (2000)	*Internet adoption (general)*	Age (-) Education (+)

off-farm income decreases the number of applications used, suggesting that online farming activities may not be as important to farmers who generate a significant amount of income away from the farm.

Most of the studies summarized above focus on finding characteristics that are associated with either the increased probability of Internet adoption or larger numbers of Internet applications used on the farm. This study extends the analysis to examine the rationale and related attributes of those farmers who choose not to use this particular technology.

Conceptual and Empirical Model

Yapa and Mayfield (1978) and more recently Gillespie, Kim, and Paudel (2007) discuss reasons or conditions why an individual would not adopt or choose not to use a new technology. These authors argue that in order for the individual to use the new technology, he must have (i) sufficient information about the technology, (ii) a favorable attitude toward the technology, (iii) financial means to acquire the technology, (iv) access to the technology, (v) a sufficient net return from using the technology, (vi) a willingness to adjust current management practices to integrate the technology, and (vii) a positive view of the applicability of the technology to his business. These conditions are not mutually exclusive, but a farm operator must view them as necessary in order to use the new technology.

To conceptualize the decision to use the Internet, a random utility model similar to Gillespie, Kim, and Paudel (2007) is presented. A farmer

will use the Internet in her farm business if the utility from use exceeds the utility from non-use. The utility a farmer gains is assumed to be a function of exogenous variables ($\mathbf{x}_{ij}$) of farmer i that makes choice j; $U_{ij}^{*} = \boldsymbol{\beta}\mathbf{x}_{ij}^{'} + e_{ij}$, where U_{ij}^{*} is an unobserved latent response, $\boldsymbol{\beta}$ is the mean response vector, and e_{ij} is a random disturbance term that is distributed iid type-1 extreme value. Although utility itself is not observed due to incomplete information on the specific benefits (and costs) associated with Internet use, we do observe the resulting outcome variable of whether or not the farmer adopts. If the ith farmer chooses to use the Internet in her farm business, then $j = 1$ (0 otherwise), and this farmer's choice maximizes her utility, or $U_{i1} > U_{i0}$.

While this exposition illustrates the binary nature of the farmer's decision to use the Internet in her farm business, it is not the primary focus of the present study. The contribution of this study is the analysis of why some farmers view the perceived benefits of using the Internet in their farm business as *not* exceeding the perceived costs. Many possible reasons could influence a household's decision not to use the Internet as part of its farm business. Some of these reasons include unfamiliarity with how to use the Internet for such a purpose, a lack of a computer, hesitancies dealing with Internet service (such as a lack of reliable broadband access), cost, concerns about Internet security, or simply a lack of perceived need. These reasons relate to one or more of the seven conditions for technology adoption discussed previously.

Given a finite number of categories for use and the underlying rationale for non-use of the Internet in the farm business, these nominal variables can be analyzed via a multinomial logit model.[2] Gillespie, Kim, and Paudel (2007) used a similar empirical approach to analyze the decision to adopt or not to adopt best management practices in the beef cattle industry. In the present study it is assumed that the choice to use or not use the Internet in the farm business depends upon individual and farm characteristics. For example, choosing not to use the Internet in the farm business because of the lack of a computer may be explained by the operator's age, farm size, or other factors.

The probability that the ith farmer selects the jth choice of using or not using the Internet in the farm business is estimated given a set of characteristics for the farmer ($\mathbf{x}_i$). Choices to be examined in this model are as follows: (i) yes, the farm operator uses the Internet in his farm business, (ii) no, the farm operator does not use the Internet in his farm business because he has no computer, (iii) no, the farm operator does not use the Internet in his farm business because of Internet security concerns, (iv) no, the farm operator does not use the Internet in his farm business because of inadequate Internet service, and (v) no, the farm operator does not use the Internet in his farm business because of some other reason. Following Greene (2002), the probability that farmer i will choose j can be expressed as

$$(1) \qquad \text{Prob}(Y_i = j \mid \mathbf{x}_i) = \frac{\exp(\beta_j^{'}\mathbf{x}_i)}{1 + \sum_{k=1}^{4}\exp(\beta_k^{'}\mathbf{x}_i)}$$

$$\text{for } j = 1, 2, \ldots 5, \text{and } \beta_5 = 0.$$

To estimate the set of probabilities (P_{ij}), the multinomial logit model must be normalized, which is done by setting the associated parameter vector for reason (v) ($\boldsymbol{\beta}_5$) equal to zero. Thus, reason (v) is the reference category. From this model, J-1 log-odds ratios are estimated. Interpreting parameter coefficients from a multinomial logit model is difficult and at times very confusing. To alleviate this confusion, marginal effects are calculated for each j choice. Marginal effects of continuous variables are calculated by taking the derivative of equation (1) with respect to $\mathbf{x}_i$, which equals $P_j\,[\boldsymbol{\beta}_j - \bar{\boldsymbol{\beta}}]$. Marginal effects of dummy variables are calculated by taking the predicted probability value when the dummy variable is one minus the value when the dummy variable is zero.

Data

Data for this study come from the 2005 Agricultural Resource Management Survey (ARMS),

[2] The multinomial logit model assumes independence from irrelevant alternatives (IIA). Greene (2002) states that IIA is not appealing when analyzing consumer behavior because it assumes that the marginal effects across alternatives are held constant. We employed the Hausman specification test for IIA following Hausman and McFadden (1984), and IIA is not rejected in our model specification, with a Chi-squared test statistic of 8.4. Therefore, the multinomial logit is an appropriate model.

which is an annual survey of farm and ranch operators administered jointly by the National Agricultural Statistics Service and the Economic Research Service of the U.S. Department of Agriculture. ARMS data contain information regarding the financial condition of farms, operational characteristics, and overall well-being of U.S. farm households. ARMS data are collected following a multi-phase, multi-frame, stratified, probability-weighted sampling design. This survey design allows the calculation of statistics that are representative of the general U.S. farm population through a set of survey sample weights. These survey weights are the inverse probability of the farm household being selected. These weights are used in the analysis below, and standard errors are estimated using the delete-a-group jackknife procedure (Dubman 2000).

Table 2 presents weighted descriptive statistics from the 2005 ARMS dataset, including general information on household and family characteristics. The variables shown in Table 2 are similar to the variables listed in Table 1, and are expected to impact the probability of using the Internet in the farm business via the signs shown in Table 1. The data represent approximately 2 million farm households.[3] Most of these farm households are "small," given the average gross farm sales of $96,000, with a standard error of $2,400. On average, a majority of the operator's labor is spent on the farm, and 82 percent of the farm operators are married. Most farms in the sample are livestock farms, and most are within 25 miles of a town with a population of at least 10,000.

The degree of rurality is an important piece to the ARRA broadband funding, and warrants closer scrutiny. Over 60 percent of the sample reside in a non-metro county (i.e., the county does not have an urbanized area of 50,000 or more inhabitants per 2000 U.S. Census guidelines). However, this classification does not clearly identify those farm households that are in more remote areas. Therefore, we use miles from a town with a population of at least 10,000 as our rurality proxy (similar to Beasley et al. 2007, Tsoodle, Featherstone, and Golden 2007, Hartley 2004). The average distance of farm households from a town of 10,000 is 24.1 miles, with a median of 18 miles. To obtain better separation between more rural farm households and those who live closer to a town of 10,000, we created categorical variables that reflect the distribution of the data. Similar to other reports (USDA 2004), only 9 percent of the sample reside more than 50 miles from a town of 10,000.

The 2005 ARMS also asked specific questions regarding Internet use as part of the farm business. As Table 2 shows, 30 percent of the representative sample use the Internet for their farm business. The remaining 70 percent were asked a follow-up question about the rationale for their decision to not use the Internet in their farm business. The respondents were asked to select one of the following reasons that best described their reason for non-use: (i) don't have computer, (ii) Internet security concerns, (iii) inadequate Internet service, and (iv) other.

The first three reasons listed—no computer, inadequate Internet service, and Internet security concerns—are popular discussion points for policymakers on why farmers may not use the Internet. Of these three reasons in Table 2, no computer is the most cited reason why the farm operator does not use the Internet in his or her farm business. Internet security concerns and inadequate Internet service account for only a small percentage of the responses, with 2 and 3 percent, respectively. The fact that so few respondents listed these two reasons as their primary basis for non-use is an interesting finding in and of itself because of its prevalence in academic studies and policy discussions.

Potentially, the Internet security concerns and inadequate Internet service as reasons for non-use have been adequately addressed, in which case some other underlying reason may exist for non-use. Support for this statement is found in the "other" category, representing 38 percent of all U.S. farm households. Some of these "other" reasons for non-use may be that the cost is too high, that there is no perceived need for their farm business, or that farm households simply have a lack of familiarity with the subject. We argue that the multinomial logit results discussed below imply that this "other" category is dominated by individuals who do not perceive the Internet as a necessary tool for their farm business.

[3] The ARMS data used are from the Cost and Returns Report. This portion of ARMS asked the Internet use question. Non-respondents to the Internet use question of interest and miles from a town of 10,000 were deleted (total of 181). Final sample size equals 6,647.

Table 2. Weighted Descriptive Statistics from 2005 Agricultural Resource Management Survey

Variable	Mean	Standard Error
Total household income ($10,000)	7.79	0.24
Gross farm sales ($10,000)	9.60	0.24
Operator's age	57.32	0.33
Percent of operator's labor spent on the farm	0.65	0.01
Number of other dependents	0.82	0.03
Number of miles from a town of 10,000		
zero = 1, otherwise 0	0.04	
1 to 25 = 1, otherwise 0	0.63	
26 to 50 = 1, otherwise 0	0.24	
51 or more = 1, otherwise 0	0.09	
Operator has a spouse = 1, otherwise 0	0.82	
Operator is white = 1, otherwise 0	0.96	
Farm primarily produces crops[a] *= 1, otherwise 0*	0.41	
Operator has a college degree = 1, otherwise 0	0.26	
Used the Internet in the farm business = 1, otherwise 0	0.30	
Did not use the Internet in the farm business because[b]		
No computer = 1, otherwise 0	0.27	
Internet security concerns = 1, otherwise 0	0.02	
Inadequate Internet service = 1, otherwise 0	0.03	
Other reasons = 1, otherwise 0	0.38	

[a] More than 50 percent of gross farm income comes from crop production.
[b] Respondents selected *one* of the four presented reasons why they did not use the Internet.

Note: Sample size is 6,647, which represents 1,959,409 U.S. farm households.

Source: 2005 ARMS Cost and Returns Report.

Results

The weighted marginal effects resulting from the weighted multinomial logit model are displayed in Table 3. The appendix shows the estimated results from the weighted multinomial logit model. The overall fit of the model is similar to the previous literature for this type of specification, as evidenced by the number of significant variables, the pseudo R^2 value of 0.12, and the percentage of correctly predicted outcomes (over 62 percent). Marginal effects of farm household characteristics on the decision to use or not use the Internet in the farm business are discussed in turn.

Yes, the Farm Operator Uses the Internet in His Farm Business

The decision to use the Internet in the farm business mostly meets *a priori* expectations. Higher levels of household income and farm sales significantly increase the probability of using the Internet for the farm business. Age displays the expected quadratic effect, with the number of older farm operators declining in the likelihood of Internet use. The education level of the operator has a positive impact on use, with a college degree leading to a 20 percent increase in the probability of use. Other results indicate that crop-producing farms are approximately 6 percent more likely to use the Internet than livestock farmers. Perhaps this result is due to pertinent crop information such as weather forecasts or grain markets being readily available on the Internet.

A few results do differ from the literature. The more time an operator or spouse spends working on the farm, the more likely they are to use the Internet in their farm business. This differs from the findings of Smith et al. (2004), who find no

Table 3. Weighted Marginal Effects of Farm Household Characteristics on the Decision to Use and the Reasons for Not Using the Internet in the Farm Business

		Do Not Use the Internet in the Farm Business Because ...			
Variable	Do Use the Internet in the Farm Business	No Computer	Internet Security Concerns	Inadequate Internet Service	Other
Total household income ($10,000)	0.0017*	-0.0055***	-0.0002	0.0004	0.0036**
Gross farm sales ($10,000)	0.0019***	-0.0018**	0.00006	0.00006	-0.00002
Operator's age	0.0216**	-0.0148**	0.0009	-0.0025	-0.0052
Operator's age squared	-0.0003***	0.0002***	-0.00001	0.00001	0.00006
Percent of operator's labor spent on farm	0.0936**	0.0426	0.0245***	0.0055	-0.1662***
Number of other dependents	0.0063	0.0023	-0.0044*	-0.0023	-0.0015
1 to 25 miles from a town of 10,000 = 1, otherwise 0 [a]	0.0050	0.0254	-0.0056	0.0410	-0.0658
26 to 50 miles from a town of 10,000 = 1, otherwise 0	-0.0333	0.0140	-0.0011	0.0951	-0.0747
51 or more miles from a town of 10,000 = 1, otherwise 0	-0.0283	0.0652	-0.0094	0.1281	-0.0157**
Operator has a spouse = 1, otherwise 0	0.1003***	-0.1722***	0.0048	-0.0024	0.0695
Operator is white = 1, otherwise 0	0.0719	-0.0101	0.0167***	0.0076	-0.0852
Farm primarily produces crops [b] *= 1, otherwise 0*	0.0504*	-0.0136	-0.0113**	-0.0213**	-0.0042
Operator has a college degree = 1, otherwise 0	0.2038***	-0.2053***	0.0009	-0.0024	0.0030

[a] The base category is 0 miles from a town of 10,000.
[b] More than 50 percent of gross farm income comes from crop production.

Notes: Marginal effects are estimated from the weighted multinomial logistic regression (pseudo R^2 = 0.12 and 62.6 percent correctly predicted). Statistical significance at the 10, 5, and 1 percent levels are identified with *, **, and ***, respectively. The 2005 ARMS sample size is 6,647, which represents 1,959,409 U.S. farm households.

significant relationship between labor and Internet use on the farm. This difference may be due to today's farms having more access to, or familiarity with, the Internet due to the normal process of diffusion. Another result at odds with the literature is that farm households located in more remote areas are just as likely to use the Internet in their farm business. This finding may be driven by the expansion of broadband access in the United States, even prior to the infrastructure investment included in the ARRA. For example, Kruger (2009) discusses the roughly $4 billion provided by the government through various loans and grants to support broadband infrastructure in rural areas since 2000. In addition, the Federal Communications Commission (2009) indicates that even in ZIP codes with the lowest population densities, 90 percent still report having broadband subscribers.

Reason for Non-Use: No Computer

One of the most vivid results in this study is the stark contrast between the factors influencing a positive response for Internet use and those influencing the choice of no computer as a reason for not using the Internet. The signs on almost all significant variables between use and non-use because of no computer are the exact opposite. That is, the factors that positively impact the probability of using the Internet have a negative impact on the probability of choosing "no computer," and vice versa. This trend holds true for total household income, gross farm sales, both age terms, the spouse's farm labor commitment, and the presence of a college degree. This result is logical and the literature supports this finding. For example, the quadratic effect of age is reversed, with the likelihood of giving no computer as a reason decreasing until age 70 and then increasing thereafter. Given older Americans' hesitancy to adopt computer technology (Belleau and Summers 1993), this result is expected. Additionally, Smith et al. (2004), Hoag, Ascough, and Frasier (1999), Amponsah (1995), and Putler and Zilberman (1988) all find that the presence of a college degree negatively impacts the likelihood that a household will not have a computer, supporting the results found here.

Reason for Non-Use: Internet Security Concerns

The third column of Table 3 displays the marginal effects for those individuals who indicated that concerns about Internet security are the primary reason they do not use the Internet for their farm business. As the farm operator works more on the farm, concerns about Internet security also increase, perhaps since farmers working off-farm are more familiar with the Internet and hence have a better understanding of Internet security measures. An additional dependent in the household decreases the likelihood of selecting Internet security concerns as a reason for non-use by 0.5 percent. This result could be because of the increased use of the Internet in today's schools, which typically includes discussions on Internet security, and may, in turn, have raised the comfort level of using and conducting business over the Internet at the household level (Goolsbee and Guryan 2006).

The presence of a white farm operator is also significant and increases the likelihood of stating that Internet security concerns are the reason for not using the Internet on the farm. This result contrasts with a recent survey that finds that white individuals are more likely to purchase goods online and thus trust Internet security measures (Horrigan 2008). Perhaps this result suggests that farmers have more concern on this topic than their general population counterparts. Crop farmers are less likely to give Internet security concerns as their reason for non-use, implying that security is more of an issue for livestock farms.

Reason for Non-Use: Inadequate Internet Service

The fourth column in Table 3 lists the marginal effects for factors associated with choosing inadequate Internet service as the reason for not using the Internet as part of the farm business. Interestingly, only the crop farm dummy variable is significant at the 5 percent level. The associated marginal effect indicates that crop farmers are less likely than livestock farmers to select this reason for not using the Internet on the farm. The most striking result regarding this reason for non-use is that none of the proxies for rurality are statistically significant. This result contrasts the findings of much research that finds that the lack of "advanced" Internet service in rural areas negatively impacts Internet adoption (see Whitacre and Mills 2007, Horrigan 2006, Prieger 2003, Strover 2003). The ARRA's broadband programs may not have a dramatic impact on Internet use by farm businesses, given the small percentage of respondents who chose this category and the lack of significance for rurality in the regression results.

Reason for Non-Use: Other

While the catch-all "other" category prevents knowledge of the exact reason for non-use, we feel that a strong argument can be made that a lack of perceived need is the dominant "other" reason. Two results in particular make this case.

First, farm household operators who chose the "other" category have a lower time commitment to the farm or are primarily employed off the farm. Further examination of the data shows that spouses of operators in this category reported the

highest percentage of off-farm labor among all spouses. Given the significant proportion of off-farm employment of these farm households and the findings of Smith et al. (2004), these households are arguably Internet savvy. Yet, using the Internet in their farm business is not something they perceive as necessary. In effect, these farm households are leisure farmers who are not overly interested in working primarily on their farm business, but rather have a farm because they enjoy it. Support for this statement is found through some simple means tests. Farms in the "other" category are smaller, in terms of gross farm sales, total farm assets, and total acres, and statistically different at the 5 percent level than farms that did use the Internet in their farm business. This argument ties nicely into the seventh condition for technology adoption discussed in the conceptual model, which deals with a positive view of the applicability of the technology for the farm operator's business.

Second, farm households with more income are more likely to select this category. If the relationship had been negative, there may have been an argument that this variable reflected cost concerns with Internet access (similar to the third condition in the conceptual model—financial means to acquire the technology). However, the positive relationship identified here more likely implies some other rationale. Combined, these two results suggest that operators who select "other" as the primary reason for non-use are implying that they do not see the need for using the Internet as part of their farm business.

Interestingly, this "other" category is the only time when a rural variable is significant. The most rural farmers (those 51 miles or more from a town of at least 10,000) are less likely to select "other" as their reason for non-use. While this may stem from the fact that farmers in very rural areas are less likely to be leisure farmers, the more important finding is the general lack of significance for rural terms throughout the results.

Conclusions and Extension Program Recommendations

The Internet has the capability to improve a farm's performance, whether through time savings due to readily available information (Rolfe, Gregor, and Menzies 2003), the creation of additional markets for both inputs and outputs (Gabriele 2004), or enhancing competitiveness (Smith et al. 2004). Although researchers have shown significant interest about how and why farms use the Internet, this study is among the first to explore explicit reasons for *not* using the Internet as part of a farm business. It takes advantage of a nationally representative farm household survey that asks respondents about their rationale for Internet non-use. Key farm and household characteristics associated with these various reasons for not using the Internet on the farm provide relevant policy and educational program discussion points aimed at increasing future levels of farm Internet use.

Results indicate that the probability of selecting "no computer" as the reason for non-use is significantly and negatively impacted by several intuitive variables, such as education, income, and the quadratic impacts of age. An unexpected result is that a measure of rurality is not significant for all non-use reasons since a multitude of research, extension programs, and political discussions have focused on increasing the availability of Internet access in rural America. This result may stem from the fact that recent policies, but prior to the ARRA, to promote broadband infrastructure in rural areas (such as the Community Connect grants and broadband loans provided by the U.S. Department of Agriculture) have reached their intended audience. Thus, the $7.2 billion investment in broadband infrastructure as part of ARRA may not result in dramatically higher numbers of farmers using the Internet as part of their farm business.

Of importance to note is that a small portion of the ARRA funds are explicitly tied to encouraging adoption—in particular, $250 million of the National Telecommunication and Information Administration funds are set aside for this purpose. The results of this study and the recommended targeted extension programming below suggest that these ARRA funds may be particularly useful for increasing Internet use by farm businesses. This statement is supported by a recent study that followed four Rural Utility Service broadband grant awardees over a three-year period, indicating that "infrastructure deployment alone is an insufficient driver, so it would be wise to encourage programs that link investments in training and use" (LaRose et al. 2008, p. 49).

Before discussing the targeted extension programs, a point to remember is that most farmers have a computer. Most farmers do not use the Internet in their farm business because of some "other" reason than the ones presented in the ARMS survey. These reasons could potentially include topics such as cost, unfamiliarity with farm-specific uses, or simply a lack of perceived need for the Internet. Future versions of ARMS should specifically include some of these reasons to allow for better insight into the decision making process. Most studies on this topic have not focused on many of these "other" reasons for non-use. Based on our findings, the emphasis on security or service has been misplaced. The multinomial logit model results show that the farm operators who selected "other" reasons for non-use spend a majority of their labor off the farm. This implies that these farm households, on average, are not as committed to working on the farm and may be considered leisure farmers. Additional work exploring the exact reason for non-use is warranted due to the high percentage of respondents who selected this category.

Regardless, the results do lend themselves to some policy and program-specific recommendations, most of which can be performed by state-level extension programs. Educational programs promoting the benefits of owning a computer in farming need to be more effectively targeted toward farm operators with lower income levels, with lower levels of education, and who are older. Additional educational programs focusing on Internet security (such as what Internet encryption entails, and how to know when a site is secure) could very easily be implemented among farm management extension programs. These programs should be aimed at those individuals who primarily work on the farm.

While future research should question the underlying rationale for those farmers that selected "other" as their reason for non-use, our results suggest that they did so due to a lack of perceived need for the technology. These farm households would benefit from educational programs that delve into various uses of the Internet for the farm business, including topics such as price monitoring, input ordering, or increasing marketing efforts. These programs should be targeted to leisure farmers or farmers that primarily work off the farm. Furthermore, as government forms and information become increasingly available online (such as eForms or farm real estate listings from the USDA), farmers may find themselves needing to know how this new online system works. These types of educational programs should be effective in helping to remove perceived obstacles to Internet use. The Internet provides many opportunities for farmers, but these numerous benefits must be conveyed in a targeted education program.

References

Amponsah, W.A. 1995. "Computer Adoption and Use of Information Services by North Carolina Commercial Farmers." *Journal of Agricultural and Applied Economics* 27(2): 565–576.

Beasley, A., J. Nelson, R. Stroschein, and J. Hamilton. 2007. "Determinants of Farmland Values in the Rapidly Developing Boise, Idaho Metro Area: Applying Mathematical Modeling to Highest and Best Use Analysis." *Journal of the American Society of Farm Managers and Rural Appraisers* 1(1): 110–117.

Belleau, B., and T. Summers. 1993. "Comparison of Selected Computer Attitude Scales." *Journal of Consumer Studies and Home Economics* 17(3): 275–282.

Dubman, R.W. 2000. "Variance Estimation with USDA's Farm Costs and Returns Surveys and Agricultural Resource Management Study Surveys." Staff Paper No. AGES 00-01, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

Ernst, S., and M. Tucker. 2001. "Perceptions and Adoption of Information Technologies: Implications for Ohio's Produce Industry in the New Economy." Working Paper No. AEDE-WP-0016-01, Department of Agricultural, Environmental, and Development Economics, Ohio State University, Columbus, OH.

Federal Communications Commission (FCC). 2009. "High-Speed Services for Internet Access: Status as of December 31, 2007." Industry Analysis and Technology Division, FCC, Washington, D.C.

Findley, H., R. Zabawa, C. Morris, and M. Oben. 1993. "Computer Awareness Among Limited-Resource Farmers." *Journal of Extension* 31(1). Available at http://www.joe.org/joe/1993spring/a8.html (accessed March 4, 2009).

Gabriele, F.I. 2004. "Internet Use and Farmers: How Did the Internet Modify the Buying Habits in the Americas?" *Brandeis Graduate Journal* 2(1): 1–13.

Gillespie, J., S.A. Kim, and K. Paudel. 2007. "Why Don't Producers Adopt Best Management Practices? An Analysis of the Beef Cattle Industry." *Agricultural Economics* 36(1): 89–102.

Gloy, B.A., and J.T. Akridge. 2000. "Computer and Internet Adoption on Large U.S. Farms." *International Food and Agribusiness Management Review* 3(1): 323–338.

Goolsbee, A., and J. Guryan. 2006. "The Impact of Internet Subsidies in Public Schools." *Review of Economics and Statistics* 88(2): 336–347.

Greene, W.H. 2002. *Econometric Analysis* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Hall, L., J. Dunkelberger, W. Ferreira, J. Prevatt, and N. Martin. 2003. "Diffusion—Adoption of Personal Computers and the Internet in Farm Business Decisions: Southeastern Beef and Peanut Farmers." *Journal of Extension* 41(3). Available at http://www.joe.org/joe/2003june/a6.shtml (accessed March 4, 2009).

Hartley, D. 2004."Rural Health Disparities, Population Health, and Rural Culture." *Rural Health and Health Care Disparities* 94(10): 1675–1678.

Hausman, J., and D. McFadden. 1984. "Specification Tests for the Multinomial Logit Model." *Econometrica* 52(5): 1219–1240.

Henderson, J., F. Dooley, and J. Akridge. 2004 "Internet and E-commerce Adoption by Agricultural Input Firms." *Review of Agricultural Economics* 26(4): 505–520.

Hoag, D., J.C. Ascough II, and W.M. Frasier. 1999. "Farm Computer Adoption in the Great Plains." *Journal of Agricultural and Applied Economics* 31(1): 57–67.

Horrigan, J. 2006. "Rural Broadband Internet Use." PEW Internet and American Life Project. Available at http://www.pewinternet.org/pdfs/PIP_Rural_Broadband.pdf (accessed November 12, 2007).

____. 2008. "Online Shopping." PEW Internet and American Life Project. Available at http://www.pewinternet.org/pdfs/PIP_Online%20Shopping.pdf (accessed March 12, 2008).

Horrigan, J., and L. Rainie. 2006. "The Internet's Growing Role in Life's Major Moments." PEW Internet and American Life Project. Available at http://www.pewinternet.org/pdfs/PIP_Major%20Moments_2006.pdf (accessed January 5, 2008).

Kruger, L.G. 2009. "Broadband Loan and Grant Programs in the USDA's Rural Utilities Service." Congressional Research Service Report for Congress No. RL33816. Available at http://www.nationalaglawcenter.org/assets/crs/RL33816.pdf (accessed January 2010).

LaRose, R., J. Gregg, S. Strover, J. Straubhaar, and N. Inagaki. 2008. "Closing the Rural Broadband Gap: Final Technical Report." Available at https://www.msu.edu/~larose/ruralbb/ (accessed January 2010).

Madden, M. 2006. "Internet Penetration and Impact." PEW Internet and American Life Project. Available at http://www.pewinternet.org/pdfs/PIP_Internet_Impact.pdf (accessed November 5, 2007).

McConnaughey, J., and W. Lader. 1998. *Falling Through the Net II: New Data on the Digital Divide*. National Telecommunications and Information Administration, Washington, D.C.

McFarlane, D., D. Chembezi, and J. Befecadu. 2003. "Internet Adoption and Use of E-commerce Strategies by Agribusiness Firms in Alabama." Selected paper for the Southern Agricultural Economics Association's annual meetings, Mobile, AL. Available at http://ageconsearch.umn.edu/ (accessed January 2010).

Mishra, A., and T. Park. 2005. "An Empirical Analysis of Internet Use by U.S. Farmers." *Agricultural and Resource Economics Review* 34(2): 253–264.

Mishra, A., and R. Williams. 2006. "Internet Access and Use by Farm Households." Paper presented at the American Agricultural Economics Association's annual meetings, Long Beach, CA. Available at http://ageconsearch.umn.edu (accessed January 2010).

Prieger, J. 2003. "The Supply Side of the Digital Divide: Is There Equal Availability in the Broadband Internet Access Market?" *Economic Inquiry* 41(2): 346–363.

Putler, D., and D. Zilberman. 1988. "Computer Use in Agriculture: Evidence from Tulare County, California." *American Journal of Agricultural Economics* 70(4): 790–802.

Rogers, E. 1962. *Diffusion of Innovations*. New York: The Free Press.

Rolfe, J., S. Gregor, and D. Menzies. 2003 "Reasons Why Farmers in Australia Adopt the Internet." *Electronic Commerce Research and Applications* 2(1): 27–41.

Smith, A., W. Goe, M. Kenney, and C. Paul. 2004. "Computer and Internet Use by Great Plains Farmers." *Journal of Agricultural and Resource Economics* 29(3): 481–500.

Strover, S. 2003. "The Prospects for Broadband Deployment in Rural America." *Government Information Quarterly* 20(2): 95–106.

Tsoodle, L.J., A.M. Featherstone, and B.B. Golden. 2007. "Combining Hedonic and Negative Exponential Techniques to Estimate the Market Value of Land." *Agricultural Finance Review* 67(2): 225–239.

U.S. Department of Agriculture. 2004. "Measuring Rurality: Rural-Urban Continuum Codes." USDA/ERS Briefing Rooms. Available at http://www.ers.usda.gov/Briefing/Rurality/ (accessed January 2010).

Whitacre, B.E., and B.F. Mills. 2007. "Infrastructure and the Rural-Urban Divide in High-Speed Residential Internet Access." *International Regional Science Review* 30(3): 249–273.

Yapa, L.S., and R.C. Mayfield. 1978. "Non-Adoption of Innovations: Evidence from Discriminant Analysis." *Economic Geography* 54(2): 145–156.

Appendix

Table A1 provides results from the estimated weighted multinomial logit model that were used to derive the weighted marginal effects presented in Table 3.

Table A1. Weighted Multinomial Logit Model of Farm Household Characteristics on the Decision to Use and the Reasons for Not Using the Internet in the Farm Business—Reference Category Is Did Not Use the Internet in the Farm Business for Some Other Reason(s)

Choice to Use	Variable	Coefficient	Standard Error	P-value
Yes, I use the Internet in my farm business	*Intercept*	-3.0907	1.2901	0.0170
	Total household income ($10,000)	-0.0023	0.0041	0.5790
	Gross farm sales ($10,000)	0.0069	0.0023	0.0020
	Operator's age	0.0859	0.0461	0.0620
	Operator's age squared	-0.0011	0.0004	0.0150
	Percent of operator's labor spent on farm	0.6993	0.2148	0.0010
	1 to 25 miles from a town of 10,000 = 1, otherwise 0[a]	0.0235	0.0513	0.6470
	26 to 50 miles from a town of 10,000 = 1, otherwise 0	0.1653	0.3128	0.5970
	50 or more miles from a town of 10,000 = 1, otherwise 0	0.0599	0.3343	0.8580
	Number of other dependents	0.3184	0.3647	0.3830
	Operator has a spouse = 1, otherwise 0	0.2250	0.2194	0.3050
	Operator is white = 1, otherwise 0	0.4593	0.3703	0.2150
	Farm primarily produces crops = 1, otherwise 0[b]	0.1808	0.1393	0.1940
	Operator has a college degree = 1, otherwise 0	0.6105	0.1524	0.0000
No, I do not because no computer	*Intercept*	0.2846	1.2279	0.8170
	Total household income ($10,000)	-0.0331	0.0117	0.0050
	Gross farm sales ($10,000)	-0.0079	0.0044	0.0710
	Operator's age	-0.0555	0.0379	0.1440
	Operator's age squared	0.0008	0.0003	0.0160
	Percent of operator's labor spent on farm	0.5701	0.2616	0.0290
	1 to 25 miles from a town of 10,000 = 1, otherwise 0	0.0138	0.0764	0.8560
	26 to 50 miles from a town of 10,000 = 1, otherwise 0	0.2656	0.3614	0.4620
	50 or more miles from a town of 10,000 = 1, otherwise 0	0.2432	0.3889	0.5320
	Number of other dependents	0.6881	0.4076	0.0910
	Operator has a spouse = 1, otherwise 0	-0.8025	0.2195	0.0000
	Operator is white = 1, otherwise 0	0.1294	0.4002	0.7460
	Farm primarily produces crops = 1, otherwise 0	-0.0527	0.1614	0.7440
	Operator has a college degree = 1, otherwise 0	-1.2267	0.2550	0.0000
No, I do not because of Internet security concerns	*Intercept*	-7.0757	3.6918	0.0550
	Total household income ($10,000)	-0.0194	0.0114	0.0880
	Gross farm sales ($10,000)	0.0038	0.0030	0.2070
	Operator's age	0.0629	0.1138	0.5800
	Operator's age squared	-0.0008	0.0009	0.4080
	Percent of operator's labor spent on farm	1.8094	0.4884	0.0000
	1 to 25 miles from a town of 10,000 = 1, otherwise 0	-0.2529	0.1649	0.1250
	26 to 50 miles from a town of 10,000 = 1, otherwise 0	-0.1681	0.7880	0.8310
	50 or more miles from a town of 10,000 = 1, otherwise 0	0.1142	0.8561	0.8940

cont'd.

Table A1 (cont'd.)

Choice to Use	Variable	Coefficient	Standard Error	P-value
	Number of other dependents	-0.3052	1.0304	0.7670
	Operator has a spouse = 1, otherwise 0	0.1438	0.5270	0.7850
	Operator is white = 1, otherwise 0	2.4019	0.7963	0.0030
	Farm primarily produces crops = 1, otherwise 0	-0.6813	0.3707	0.0660
	Operator has a college degree = 1, otherwise 0	0.0477	0.3733	0.8980
No, I do not because of inadequate Internet service	*Intercept*	-1.8535	2.3303	0.4260
	Total household income ($10,000)	0.0051	0.0090	0.5690
	Gross farm sales ($10,000)	0.0021	0.0038	0.5810
	Operator's age	-0.0682	0.0771	0.3760
	Operator's age squared	0.0003	0.0007	0.6350
	Percent of operator's labor spent on farm	0.5536	0.5020	0.2700
	1 to 25 miles from a town of 10,000 = 1, otherwise 0	-0.0712	0.1007	0.4790
	26 to 50 miles from a town of 10,000 = 1, otherwise 0	1.6175	0.9902	0.1020
	50 or more miles from a town of 10,000 = 1, otherwise 0	1.9265	0.9985	0.0540
	Number of other dependents	2.2011	1.0417	0.0350
	Operator has a spouse = 1, otherwise 0	-0.2436	0.4225	0.5640
	Operator is white = 1, otherwise 0	0.4590	0.6777	0.4980
	Farm primarily produces crops = 1, otherwise 0	-0.7131	0.3266	0.0290
	Operator has a college degree = 1, otherwise 0	-0.0906	0.3954	0.8190

[a] The base category is 0 miles from a town of 10,000.
[b] More than 50 percent of gross farm income comes from crop production.

Notes: Pseudo R^2 = 0.12; 62.6 percent correctly predicted; log likelihood = -7,436.13; Wald χ^2 = 359.70 with a p-value = 0.0000. The 2005 ARMS Cost and Returns Report sample size is 6,647, which represents 1,959,409 U.S. farm households.