Internet Usage by Farmers: Evidence from a National Survey

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Abstract

The Internet may reduce constraints on a farmer's ability to receive and manage information, regardless of where the farm is located or when the information is used. Using a Count data estimation procedure, this study attempts to examine the key farm, operator, regional, and household characteristics that influence the number of Internet applications used by farm households. Results indicate that educational level of the farm operator, farm size, farm diversification, off-farm income, off-farm investments, and regional location of the farm have significant impact on the number of Internet applications.

Keywords: Computers, count-data method, education, farm households, Internet applications.

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The Internet has changed the world. People can now access up-to-the minute information at the touch of a button and can also communicate and engage in trading activities on-line. This electronic revolution has changed the business world but has it affected the world of farming? USDA recently reported that the use of computers on farms has grown from 38 to 55 percent since 1997, while Internet use on farms has grown from 13 to 43 percent (USDA, *Agricultural Economics and Land Ownership Survey*). Farmers are also beginning to embrace e-business and successfully trade on-line. As a technology, the Internet has the additional benefit of minimizing some constraints on a farmer's ability to receive and manage information, regardless of where the farm is located or when the information is used. Internet- provided communication and information gathering services are generally available at substantially lower costs than conventional technology. Consequently, the commercial opportunities of the Internet may afford farmers new ways to build business partnerships, including opportunities to purchase inputs, sell farm products, and acquire new agricultural information. Many agricultural groups, researchers, farm organizations, teachers, and extension agents have taken an active interest in Internet use in agriculture.

Despite this interest, little analysis of Internet use patterns in agriculture has occurred. Understanding the factors that influence farm-level Internet use will assist in developing successful Internet applications used by farmers, innovations, and wider use of this technology. This study attempts to examine the key farm, operator, regional, and household characteristics that influence the number of Internet applications. Rather than estimating a likelihood of adoption (0,1) logit model, as is the case in most of the adoption literature, our study estimates the number of specific types of Internet applications that a farm operator reports using. These types include paying bills, obtaining loans, input and commodity price tracking, contact with advisory services, and obtaining information from USDA and other sources. We go beyond whether or not adoption has occurred because there is not much that has been done in the way of how farmers are using the Internet or why are they using it. Furthermore, because the Internet has "gradations" of adoption one must go beyond the logit to understand past growth and predict it in the future. The analysis is conducted on a national level with the unique feature of a larger sample than previously reported, comprising farms of different economic sizes and in different regions of the United States.

Previous Studies

Agricultural businesses increasingly use information as an input in the production process. Rapid development of computer and telecommunication technologies in the 1990s and corresponding reductions in their costs have increased the capability of computers to assist business managers in the collection, storage, and processing of information. Using 1987 Farm Costs and Returns data, Willimack found that less than 3 percent of U.S. farmers used a computer to maintain farm records. Lazarus and Smith found that 15 percent of New York dairy farmers enrolled in the Farm Business Summary and Analysis program owned computers in 1986. A follow-up study by Lazarus, Streeter, and Jofre-Giraudo tracked a panel of record keeping farmers over a four-year period and found an increasing cumulative adoption pattern. Putler and Zilberman surveyed farmers in Tulare County, California and found that over 25 percent of farmers owned computers.

Computer adoption rates by farmers vary with operator and business characteristics. Survey results by Willimack, Lazarus and Smith, and *Farm Futures* found an inverse relationship between adoption rates and farmer age. Consistent with Putler and Zilberman these studies found that higher education and larger business sizes were positively related to computer adoption rates. Willimack found higher adoption rates for crop farmers than livestock farmers. However, Putler and Zilberman found a positive relationship between adoption and livestock producers and a negative relationship between adoption and crop farmers. Willimack also found regional differences in adoption rates.

Farm operators used computers for different activities. For example, the majority of farmers use computers for financial accounting, preparation of financial statements, production record keeping, and word processing. Our research is different than those mentioned above. We do not look at the adoption of computers, but we are interested in the issue of how farm operators use the Internet. Furthermore, Internet adoption has gradations compared to the any other technology adoption case (0,1) which uses logit model. In particular we are interested in investigating those factors that affect the number of operations (different types of applications) that a farm operator performs using the Internet.

Estimation Procedure

In order to analyze the effects of various farm, operator, and regional characteristics on the number of Internet applications (the Internet could be used for a number of purposes such as paying bills, obtaining loans, online banking, input or output tracking, record keeping, etc.) we adopt the method employed in patent literature (see Hausman *et al.*,; Cameron and Trivedi;

Cincera; and others). In our study the number of Internet uses is a function of a set of independent variables ($\mathbf{X}_i$) outlined in the previous section.

$$\mathrm{Ln}(\lambda_i) = \alpha_0 + \mathbf{X}_i\beta \tag{1}$$

where λ_i is the number of Internet uses or applications by farm operator i. Data on the number of Internet applications/uses constitute a nonnegative integer valued random variable. The classical linear model fails to recognize this feature and hence is not appropriate. However, several authors (Hausman *et al.,*; Cameron and Trivedi; and Cincera) have presented and discussed count data models as an alternative method.[1] In the count data model the primary variables of interest are event counts. In our analysis, we consider the Poisson and the negative binomial models, which are within the linear exponential family, for analyzing the number of Internet applications/uses by farm operators. Before presenting the estimated model we will briefly describe the Poisson and negative binomial models.

The Poisson Model

Let Y_i be the observed event (number of Internet uses) count for the ith farm operator. The Y_i are assumed to be independent and have a Poisson distribution with parameters λ_i. The parameters λ_i depend on a set of explanatory variables (X_i) which are in this case the factors affecting the number of Internet application/uses by a farm operator.

$$\lambda_i = \exp(X_i\beta) \tag{2}$$

where X_i represents the set of explanatory variables, and β is the vector of parameters to be estimated. The basic probability density function for the Poisson model is given by:

$$\Pr(Y_i) = f(Y_i) = \left[\frac{e^{-\lambda_i}\lambda_i^{Y_i}}{Y_i!}\right] \tag{3}$$

The Poisson specification assumes that the mean of Y_i is equal to its variance.

The Negative Binomial Model

The negative binomial model, which is more flexible than the Poisson, λ_i is assumed to follow a gamma distribution with parameters (γ, δ), where $\gamma = \exp(X_i\beta)$ and δ is common across time. Then, the gamma distribution for λ_i is integrated by parts to obtain a negative binomial distribution with parameters ($\gamma_{i,}$ δ). Specifically,

$$\Pr(Y_i) = \int_0^\infty \frac{1}{Y_i} e^{-\lambda_i} \lambda_i^{Y_i} f(\lambda_i) d\lambda_i \quad (4)$$

Using the above framework suggests that the number of Internet uses by a farm operator is expressed as a function of various farm, operator, household, and regional characteristics. Specifically, $\lambda_i = \exp(X_i\beta)$ where X_i is a set of explanatory variables such as age and education of the operator, farm size, diversification, contracting, regional dummies, etc.

A subsequent question then arises as to which model (Poisson or negative binomial) is more appropriate. Cameron and Trivedi have proposed a number of tests for the over- or underdispersion in the Poisson regression model. They basically test for the underlying assumption, mean-variance equality, of the Poisson model. Under the null hypothesis, $H_0 : \text{var}(Y_i) = \mu_i$. The specific alternative hypothesis is that $H_1 : \text{var}(Y_i) = \mu_i + \alpha * g(\mu_i)$, where g(.) is a specified function that maps from R^+ to R^+. Tests for overdispersion or underdispersion are tests of whether $\alpha = 0$. We use a similar test in our study.

[1] See Winkelmann and Zimmermann for a recent overview of count data models.

The choice of attributes associated with the number of Internet applications used is guided by human capital theory, farm and production characteristics, and other adoption models. Studies by Nelson and Phelps; Khaldi; and Wozniak (1989) use education as a measure of human capital to reflect the ability to adopt innovation (either technology or insurance).

Data

Data for the analysis are from the 2000 Agricultural Resources Management Survey (ARMS). ARMS is conducted annually by the Economic Research Service and the National Agricultural Statistics Service. The survey collects data to measure the financial condition (farm income, expenses, assets, and debts) and operating characteristics of farm businesses, the cost of producing agricultural commodities, and the well-being of farm operator households.

The target population of the survey is operators associated with farm businesses representing agricultural production in the 48 contiguous states. A farm is defined as an establishment that sold or normally would have sold at least $1,000 of agricultural products during the year. Farms can be organized as proprietorships, partnerships, family corporations, nonfamily corporations, or cooperatives. Data are collected from one operator per farm, the senior farm operator. A senior farm operator is the operator who makes most of the day-to-day management decisions. For the purpose of this study, operator households organized as nonfamily corporations or cooperatives and farms run by hired managers were excluded.

The 2000 ARMS survey queried farmers on all types of financial, communication, and information-gathering activities as well as their online buying and selling of crops and livestock. Farms using the Internet reported implementing the technology for a number of different reasons: (1) price tracking (83%); (2) agricultural information services (56%); (3) accessing information from USDA (33%); and (4) online record keeping and data transmission to clients. The independent variable (number of Internet uses/applications) was obtained by summing the number of applications or operations that the farmer reported doing through the Internet. In this case a farm operator could have indicated using internet, but may have not used any of the applications that the survey queried.

The State New Economy Index (SCORE1999) is used as an indicator of high technology, internet, and new economy characteristics of states. The 1999 Index is based on 17 indicators in five broad categories relating to knowledge jobs, globalization, economic dynamism and competition, and digital economy measures and technological innovation capacity. The digital economy sub-index measures factors such as the percentage of adults online, commercial internet domain names per firm, the deployment and use of information technology in K-12 public schools and the use of digital technologies to deliver state government services.

The overall scores for the states reveal that Massachusetts, California, and Colorado (with scores above 70) rank the highest on the new economy measures. States that score lower on the index have historically lagged behind in industrialization patterns and include a group of ten states (Mississippi, Arkansas, West Virginia, Louisiana, Montana, North Dakota, Alabama, South Dakota, Iowa, and Wyoming) with scores below 35. Summary statistics for each of the variables utilized in the analysis are presented in Table 1.

Results

The estimates of the dispersion parameter clearly indicate that a negative binomial specification is appropriate (Cameron and Trivedi). Tests show, not reported here, evidence of overdispersion in the data used. Estimated model parameters for the negative binomial model are presented in Table 2. The overall fit of the model is good as indicated by the number of significant variables. The correlation between observed and predicted values is in the range of 67 percent. Caution is emphasized in using these statistics. Computing measures similar to R^2 can be complex and misleading in count data models.

The State New Economy Index (SCORE1999) has little explanatory power influencing the number of Internet applications adopted by farmers. Atkinson et al. acknowledge the difficulty of measuring the new economy at the state level as the most useful data are typically available at the national level. In addition, a main feature of the information technology revolution is the emergence of regional clusters of innovations that may not be closely correlated with state economic activity.

Unlike previous studies in computer adoption we do not find age of the operator to be significant, however the coefficient on both age (OP_AGE) and age squared have the expected sign. The estimated coefficient for OP_EDUC is positive and significant at the 5 percent level of significance. Increased education is expected to increase understanding of the complexities of production and financial relationships and therefore increase demand for information. This is consistent with the arguments suggested by Welch; Rahm and Huffman. Additionally, increased education corresponds to an increased awareness of the capabilities to judge their (computers and information gathered through them) usefulness to the business. Results suggest that an additional year of education increases the number of Internet uses by farm operators by 2.6 percent, holding all other variables constant. Our findings are consistent with Willimack; Putler and Zilberman; Lazarus and Smith, who studied the adoption of computers by farmers. The coefficient for farm size, measured by the value of agricultural commodities sold by the farm (F_VALPROD), is positive and significant at the 1 percent level of significance. One argument is that large farms face more complex decisions so that the value of information required is greater. Also, large farms that produce a majority of the products are on the cutting edge of adopting new ways both in production and marketing to increase farm profitability.

Diversification, as measured by an entropy index (F_DIVERS), which was popularized by Theil, is used as a explanatory variable in the model, because of the several desirable properties it possesses (*see* Hackbart and Anderson). The index[2] takes a value of 1 when a farm is completely diversified and 0 when a farm is specialized (Theil 1972). Specifically, an entropy measure of farm diversification considers the number of enterprises a farm participates in and the relative importance of each enterprise to the farm. An operation with many enterprises, but with one predominant enterprise, would have a lower number on the diversification index. Higher index numbers go to the operations that distribute their production more equally among several enterprises. It is assumed that diversification may lead to economies of scope, which lower costs and increase profits. Hence, operators of diversified farms require more information for both

[2] $E.I = \sum_{i=1}^{N} \frac{\text{(\% production from enterprise i) * Ln(\% production from enterprise i)}}{Ln(\text{number of possible enterprises})}$, where i refers to each of the N possible enterprises.

producing and marketing their products. It is our assumption that operators of such farms will use the Internet far more than others.

The coefficient on F_DIVERS is positive and statistically significant at the 1 percent level of significance. A plausible explanation is that diversified farms may be using the Internet to track input and output prices, information related to enterprises (crops and livestock), production management, and marketing. Additionally, diversified farms also tend to be larger in economic size. One of the interesting findings is the negative and statistically significant relationship between off-farm income (OF_WORK) and number of Internet uses by farm operators. Results suggest that farm households that receive off-farm income in the form of wages and salaries (a proxy for a permanent off-farm job) are likely to use the Internet in fewer applications. A possible explanation for this is that many of the operations (or uses) that the farm operator was asked about relate to farming and information gathering about farming. Additionally, as one reviewer pointed out, wage and salary income is most likely earned by small and intermediate size farms—where the activities ARMS asked about might not be as important. Likewise these smaller operations tend to focus on commodities like beef cows. Operators of large farms have more sources of off-farm income including other self-employment sources. Under such circumstances one can conceive there being a negative relationship between off-farm income and number of Internet uses by farm operators.

The coefficient on F_INVEST is positive and statistically significant at the 1 percent level of significance. Results suggest that farm households that receive interest and dividends engage in more Internet applications. This may be reflecting the fact that a household that receives interest and dividends are more sophisticated in their investments, more likely to be educated, and have higher household income, and hence, have the ability to use different Internet applications (such as searching the Internet for loans, products, marketing, or information). Farm operators who have marketing contracts (M_CONTRACT), contracted sales of their crops, livestock, and other commodities, are also likely to use more Internet applications. One possible explanation is that farmers who engage in production or marketing contracts are risk averse and are constantly seeking ways to increase their profits. Various Internet applications can provide a farmer with information about prices of output and inputs, discounted prices for inputs, information regarding production agriculture, and new technology.

Geographic location of farms determines cropping patterns, rainfall amounts, and soil productivity. Nine regional dummies, created by the Economic Research Service, USDA, were used in the analysis (for details see Lipton). The Mississippi Portal Region was used as the benchmark, therefore any significance of coefficients on regional dummies is relative to the benchmark region (Mississippi Portal). The coefficient on the Heartland region (R_HEART) is positive and statistically significant at the 10 percent level of significance. Results indicate that farms located in the Heartland region are using more Internet applications compared to farms in the benchmark region (Mississippi Portal). Farms in the Heartland regions produce 23 percent of US farm output and have the most cropland (27%) and tend to be larger farms. These farms tend to grow cash grains, cattle, and some dairy. The coefficients on Eastern Upland (R_EUPLAND) and Fruitful Rim (R_FRIM) are positive and statistically significant at the 1 percent level of significance. Results indicate that farms located in the Eastern Upland and Fruitful Rim regions are using more Internet applications compared to farms in the benchmark region (Mississippi

Portal). The Eastern Uplands have the highest number of small farms of any region and these farms are diversified with tobacco, poultry, cattle, and some cash grains. On the other hand farms in the Fruitful Rim tend to grow high valued crops such as fruits, vegetables, nursery, and cotton, and are mostly diversified farms. It is likely that the region variables represent the effects of omitted variables that are correlated with regional location (e.g., the intensity of advertising by Internet providers, transactions costs) of farm households.

Concluding Comments

The Internet may reduce constraints on a farmer's ability to receive and manage information, regardless of where the farm is located or when the information is accessed. Many agricultural groups, researchers, farm organizations, teachers, and extension agents have taken an active interest in Internet use in agriculture. This study examined the key farm, operator, regional, and household characteristics that influence the number of Internet applications used by farm households. This study is unique in two aspects. First, we use national farm-level data comprised of different farm types and farm locations. Second this study is the first to use the Count data estimation method to investigate the impact of various factors affecting the number of Internet applications employed by farm operators.

Results from this study indicate that the number of Internet applications is directly and significantly correlated with the educational level of the farm operator, farm size, farm diversification, presence of marketing contracts, and locations of farms. Overall, the results indicate more number of Internet applications toward more educated and large farm operators. If the benefits of Internet are to be enjoyed more widely, this suggests that special efforts may be needed to target small farmers and less-educated farmers. Further, emphasis might need to be targeted more to smaller operators who are in the beginning stages of farming, producers who would like to learn more and become more proficient at examining marketing data and trends for commodities, or households that might not be operating a large farm but instead might be tracking off-farm investments.

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Table 1: Variable definitions and Summary Statistics

Variable name	Description	Mean (Std. Dev)
OP_EDUC	Education level of farm operator	13.89
OP_AGE	Age of the farm operator (years)	48.0
F_DIVERS	Entropy measure of farm diversification	0.20
OF_WAGE	=1 if household reports off-farm income through wages and salaries, 0 otherwise	0.64
SCORE1999	Internet access score	45.17
F_VALPROD	Value of agricultural commodities sold by the farm *($0,000)*	59.79
P_CONTRACT	=1 if the farm had production contract, 0 otherwise	0.14
M_CONTRACT	=1 if the farm had marketing contract, 0 otherwise.	0.32
F_INVEST	=1 if the farm household received interest and dividends, 0 otherwise	0.68
R_HEART	=1 if the farm is located in the Heartland region of the U.S., 0 otherwise	0.21
R_NORTHC	=1 if the farm is located in the Northern Crescent region of the U.S., 0 otherwise	0.15
R_NORTHGP	=1 if the farm is located in the Northern Great Plain region of the U.S., 0 otherwise	0.08
R_PGATE	=1 if the farm is located in the Prairie Gateway region of the U.S., 0 otherwise	0.14
R_EUPLAND	=1 if the farm is located in the Eastern Upland region of the U.S., 0 otherwise	0.08
R_SSBOARD	=1 if the farm is located in the Southern Seaboard region of the U.S., 0 otherwise	0.13
R_FRIM	=1 if the farm is located in the Fruitful Rim region of the U.S., 0 otherwise	0.10
R_BASINR	=1 if the farm is located in the Basin Range region of the U.S., 0 otherwise	0.06
INT_APPL	Number of Internet applications used by farmers (*Independent variable*)	3.26
	Sample	*2,138*

Table 2: Effect of farm, operator, and regional characteristics on number of Internet uses (Negative Binomial Model).

Variable names	Parameter estimates
Intercept	0.557**
	(0.262)
OP_EDUC	0.026**
	(0.008)
OP_AGE	0.006
	(0.009)
OP_AGESQ	-0.000
	(0.000)
F_DIVERS	0.232***
	(0.115)
OF_WAGE	-0.071***
	(0.034)
SCORE1999	0.001
	(0.001)
F_VALPROD	0.600E-03***
	(0.165E-03)
F_VALPRODSQ	-0.138E-06
	(0.168E-06)
P_CONTRACT	0.046
	(0.044)
M_CONTRACT	0.066***
	(0.030)
F_INVEST	0.077***
	(0.029)
R_HEART	0.149*
	(0.088)
R_NORTHC	0.069
	(0.091)
R_NORTHGP	0.135
	(0.096)
R_PGATE	0.123
	(0.091)
R_EUPLAND	0.349***
	(0.087)
R_SSBOARD	0.028
	(0.094)
R_FRIM	0.319***
	(0.095)
R_BASINR	0.134
	(0.106)
Log-Likelihood	-3500.34
Correlation between observed and predicted	0.67

Numbers in parentheses are standard errors. Single, double, and triple asterisks show statistical significance at 10%, 5%, 1% levels, respectively.