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Computer and internet adoption on large U.S. farms

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Abstract

The adoption of the personal computer and the Internet is studied within a sample of large U.S. farms. Factors such as age and education influence the adoption of both technologies. Likewise, strong relationships exist between the adoption of each technology and the sophistication of farm management and the complexity of the farm business. After controlling for computer adoption, the results suggest there remain several factors limiting Internet adoption. It appears that producers are unsure as to how the Internet can best be used to create value in their farm businesses.

1. Introduction

The personal computer (PC) has become an important management tool on many U.S. farms. The PC enables managers to easily and accurately keep financial records, track production processes, summarize data, and generally assist managerial decision-making. Recently, the Internet has emerged as an information technology that has many potential benefits and applications for U.S. farmers. The Internet can be used by producers to access price and product information, access government and university reports and research, interact with other producers and specialists, purchase inputs, sell production, communicate with suppliers and customers, and access application software, among other uses.

Although the adoption of the PC is virtually a necessary action for adoption of the Internet, as a technology the Internet has many characteristics that differentiate it from the PC. For instance, the PC is frequently used to process and manipulate a farm's internal data, while

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Table 1
Estimates of the number of farms using the PC

Study	Population	Time	Percent adopting the PC
Huffman and Mercier	Iowa farms	1982–1984	6.2%
Putler and Zilberman	California farms	1986	25.6%
Batte, Jones, and Schnitkey	Ohio farms	1987	24%
Baker	New Mexico nonfarm agribusinesses	1987	44%
Fearne	British farms	1988	12% to 47%
Jarvis	Texas rice growers	1990	37%
Ortmann, Patrick, and Musser	Large corn belt farms	1991	80%
Amponsah	North Carolina farms	1991	14.4%
Nuthall and Bishop–Hurley	New Zealand farms	1992	33.6%
Lewis	Australian farmers	1995	30%
NASS	U.S. farms with sales over $100,000	1999	68%

the Internet allows the farmer to acquire and analyze external data and information. The Internet also provides farmers a convenient environment with which to communicate and transact business with buyers, suppliers, specialists, and other farmers.

Unlike PC use, Internet use in agriculture is a relatively recent phenomenon. There are few published studies of Internet use by farmers, and there is little evidence regarding the factors that influence Internet adoption. By determining the proportion of commercial farms that use the Internet and the factors that influence Internet adoption, input suppliers can begin the process of opportunity and threat identification necessary for the development of strategies that make use of the Internet. In addition, educational institutions and government agencies can better understand how the Internet might be used to interact with large U.S. farms.

According to a 1999 National Agricultural Statistics Service (NASS) report, 68% of U.S. farms with annual sales over $100,000 had computer access and 43% had Internet access. This and other studies of farm computer adoption have shown that computer adoption varies considerably with the farm population under study. Table 1 lists several estimates of computer adoption for various farm populations. Although the estimates are not homogeneous with respect to population or time, these analyses have consistently found a relationship between computer adoption and farm size, the age of the primary decision-maker, and the educational background of the primary decision-maker.

Many previous studies have examined computer adoption within a subset of farm groups (farms from a specific county in California; North Carolina farms; Iowa farms; Texas rice growers; Ohio commercial farms; large cornbelt farms). We examine PC adoption on U.S. farms that generate $100,000 in annual sales and produce some combination of six commodities. Next, we examine Internet adoption on these same farms. In doing so, we identify the proportion of the members of this important market segment currently using the Internet, what they are using the Internet for, and the factors that influence Internet adoption.

In the next section the factors identified by previous studies as possible explanations for

PC adoption are presented. Then, the data, hypothesized relationships, and models for both PC and Internet adoption are presented. The results of the analysis and conclusions regarding PC and Internet adoption on large farms are given in the last section.

2. Background

Computer adoption on U.S. farms has been studied by many researchers (Amponsah, 1995; Ortmann, Patrick, and Musser, 1994; Huffman and Mercier, 1991; Batte, Jones, and Schnitkey, 1990; Jarvis, 1990; Putler and Zilberman, 1988). In general, these researchers have found both personal and business characteristics to be related to PC adoption. Some of the personal characteristics found to be related to PC adoption include level of education, age, and off-farm employment. All of the above studies except Jarvis (1990) found a significant relationship between a farmer's educational level and PC adoption. Only Jarvis (1990) and Amponsah (1995) failed to find a significant relationship between the age of the primary decision-maker and PC adoption. Huffman and Mercier (1991) found that off-farm employment was negatively related to PC adoption. However, Jarvis (1990) found no relationship between the percentage of gross farm income generated by off-farm sources and the probability of PC adoption.

These results for farms can be contrasted with those of Baker (1992) who studied PC adoption in nonfarm agribusinesses. Baker (1992) found no support for a relationship between personal characteristics and PC adoption. He hypothesized that the lack of a relationship between personal characteristics and PC adoption was because of more decentralized decision making processes in nonfarm agribusinesses.

Business characteristics such as experience with other technology, the use of farm records services, the use of consultants, the size of the farm business, the complexity of the farm business, the level of farm income, the type of commodities produced by the farm, and the number of employees have been hypothesized to affect PC adoption (Lewis, 1998; Amponsah, 1995; Baker, 1992; Huffman and Mercier, 1991; Batte, Jones, Schnitkey, 1990; Jarvis, 1990; Putler and Zilberman, 1988). There is less consistency in the relationship between PC adoption and business characteristics than that found between PC adoption and personal characteristics. It appears that there is a positive relationship between measures of farm size and PC adoption (Amponsah, 1995; Ortmann, Patrick, and Musser, 1994; Batte, Jones, and Schnitkey, 1990; Putler and Zilberman, 1988). Although related to farm size, increases in the complexity of the farming operation have also been found to be related to PC adoption (Huffman and Mercier, 1991; Jarvis, 1990). Researchers have also documented relationships between the production of specific commodities (dairy, corn, cotton, etc.) and computer adoption (Huffman and Mercier, 1991; Batte, Jones, and Schnitkey, 1990; Jarvis, 1990).

These studies have taken the perspective that the computer is an integral tool for turning farm data into information upon which management can act. In other words, the computer is a key element of the managerial information system (MIS) on most farms. Lewis (1998) describes how the sophistication of farm MIS systems has progressed from manual systems to computerized systems. He suggests that the next step in the evolution of the farm MIS system is Internet use.

An important characteristic of the Internet based MIS system is its ability to transcend information gathering and processing. Thus, although the Internet can be viewed as a modest technological extension of the PC, its implementation and business function could be argued to be very different from the PC's. If this is true, it is likely that the factors that drive PC and Internet adoption will differ.

Studies of the general U.S. population suggest that factors such as education, household income, profession, and age impact Internet adoption by consumers (Lake, 1999). Because these factors have frequently been associated with PC adoption, this would tend to suggest that similar factors determine Internet adoption on U.S. farms. Unfortunately, it is not clear that these studies have controlled for PC adoption or whether the suggested relationships between Internet adoption and the explanatory factors merely reflect the PC adoption decision.

There is considerable variation in the estimates of the size of the U.S. population using the Internet. For instance, Lake (1999) reports that studies of Internet adoption in the general U.S. population have produced estimates of 60 to 100 million households using the Internet. Within the U.S. farm population, Internet adoption in 1999 was estimated at 43% for U.S. farms with sales over $100,000 (NASS, 1999). While these studies estimate Internet adoption, they do not present rigorous analyses of the factors that influence adoption. This study addresses these shortcomings and focuses on a smaller segment of the nation's farms, commercial farms (sales in excess of $100,000). Although accounting for only 16.7% of U.S. farms in 1997, these farms are an extremely important market segment for most agricultural input suppliers as they generate 77.3% of the farm sector's cash expenditures (Resource Economics Division, Economic Research Service, 1998).

3. Data

The data used to examine PC and Internet adoption come from a mail survey of 10,500 U.S. farms with sales in excess of $100,000. The farms were identified from a proprietary database and were selected to meet geographical, farm size, and enterprise targets. With respect to enterprises, farms were targeted according to the predominance of corn/soybeans, wheat/barley, cotton, dairy, beef, and hog operations on farms in the database. Details of the sampling procedure can be found in Akridge et al. (2000) or Gloy (1999).

The initial survey instrument was pretested with farmers in February 1998. After modification, the final survey instrument and a postage paid reply envelope were mailed in March 1998. A follow-up reminder card was sent approximately two weeks after the initial mailing. Next, calls were made to nonrespondents in late March. Data collection ended in April 1998.

Because the survey instrument was quite long, the farms large, and a copy of the results were offered as an incentive for participation (no monetary incentive was employed), the anticipated response was 20%. Of the 10,500 surveys sent, 1,742 usable questionnaires were returned, for a response rate of 16.6%. Corn/soybean growers accounted for the largest percentage of respondents and wheat/barley growers the fewest. The actual response indicated that the expected response rates were slightly overestimated in all enterprises except corn/soybeans. Nearly 61% of the respondents had one enterprise that generated sales of at

Table 2
Personal computer and Internet use by large U.S. farms

Computer Use	Percent using*
Use a computer to keep financial records	68%
Use a computer for production planning	39%
Use a computer for communications (Internet, Fax, etc.)	38%
Do not own a computer on my farm	17%
Hire a computer farm records service	12%
Own a computer, but do not use it much for farm business	10%
Internet use	
Do not use Internet	51%
Obtain product related information	30%
Obtain market related information	26%
Obtain management information	16%
Place orders for products	5%
Participate in a "chat" group	5%
Do not use Internet for farm business purposes	5%
Sell or market my products	2%

* $N = 1{,}662$.

least $500,000 and the remainder had one enterprise with sales of at least $100,000. Further description of the sampling procedure and the characteristics of the sample can be found in the appendix. A thorough description of the sampling procedure, survey instrument, and an analysis of the correspondence between the expected and actual samples can be found in Akridge et al. (2000) or Gloy (1999).

Respondents were asked several questions related to their farm's use of the PC and Internet. Table 2 shows the percentage of respondents using the PC and Internet for various purposes. The results indicate that 83% of the respondents own a computer. The most popular use of the computer was financial record keeping which was computer assisted on 68% of the farms. Nearly as many commercial producers indicated that they were using the PC for communications (Internet, fax, etc.) (38%) as indicated that they used the PC for production planning purposes (39%).

Nearly half of the respondents indicated that they were using the Internet. The most popular uses of the Internet were obtaining product-related information (30% of respondents) and obtaining market related information (26% of respondents). Only 5% of the respondents had used the Internet to make a purchase, and 2% had sold or marketed a product on the Internet. Thus, it appears that in Spring 1998 the majority of the producers adopting the Internet were using it as a means for gathering external information.

Input suppliers, educational institutions, and government agencies seeking to communicate and conduct business with commercial producers on the Internet will find it important to understand the factors that encourage or discourage PC and Internet adoption. This knowledge will increase their understanding of the characteristics, motivations, and needs of producers adopting these technologies. Because the decision to adopt is a binary choice (0 = no, 1 = yes), logistic regression is well suited to predict the probability of adoption as a function of several characteristics hypothesized to influence adoption. When modeling Internet adoption, it is crucial to account for the sequential nature of the PC-Internet adoption

process. Because it is virtually necessary to adopt the PC to use the Internet, this is accomplished by estimating the Internet adoption model within the population of producers who have adopted the PC. An alternative view of the adoption decision is that the PC-Internet adoption decision is a joint decision in which producers adopt the PC to access the Internet. Previous studies of the commercial producer marketplace show that computer adoption was 70% in 1993 (Center for Agricultural Business, 1993). Because such a large proportion of commercial farmers had previously adopted the PC, it appears that for commercial farmers the sequential adoption process is more appropriate than the joint adoption process. The next section describes the characteristics hypothesized to influence computer and Internet adoption.

4. Description of the variables

Age (AGE_i) and education level ($EDUC_i$) of the farm's primary decision-maker are the personal characteristics included in the adoption models. Consistent with previous studies, it is expected that age will be negatively related to PC adoption and education level will be positively related to PC adoption. Older producers have more established information processing routines and thus have less to gain by adopting the PC (Lewis, 1998; Amponsah, 1995; Batte, Jones, Schnitkey, 1990). Likewise, older producers are likely to have less experience with computers (Putler and Zilberman, 1988). Batte, Jones, and Schnitkey (1990) suggest that computer adoption is unlike adoption of technologies such as hybrid seeds because PC adoption requires substantial learning. Increasing levels of education should be consistent with the ability to learn to use a PC and create value from the information produced by the PC (Amponsah, 1995; Huffman and Mercier, 1991; Batte, Jones, and Schnitkey, 1990; Putler and Zilberman, 1988). Thus, older and less educated producers will be less likely to invest in the learning required to adopt the PC.

After controlling for PC adoption, one can make strong arguments why the age (AGE_i) of the primary decision-maker might have either a negative impact or no meaningful impact on the probability of Internet adoption. Following the learning argument, it would be reasonable to suggest that the additional investment in learning associated with Internet adoption is much less than that associated with PC adoption. In other words, once it is economically reasonable to cross the learning threshold and adopt the PC, the marginal cost of the learning required to adopt the Internet is modest. Therefore, within the population of PC adopters, it could be expected that age (AGE_i) should not be strongly related to Internet adoption. On the other hand, one could argue that the benefits offered by the Internet are much different than those offered by the PC. Thus, even though the PC is needed to use the Internet, the knowledge required to use the PC does not prepare the producer to use the Internet. If this were true, one would expect that within the population of PC adopters, increasing age would reduce the probability of Internet adoption.

With respect to education level, it is expected that better educated managers are more likely to be able to realize the benefits of the Internet. At this point, one of the primary benefits of the Internet is its ability to lower the cost of information gathering. The more educated the manager, the more likely they are to benefit from easier access to information.

Therefore, it is expected that education level, ($EDUC_i$) will be positively related to Internet adoption within the population of PC adopters.

Establishing a computer system has relatively high fixed costs and small marginal costs. Because larger farms generate more transactions, as size increases larger farms are better able to recover the fixed costs of adoption. Therefore, farm size (*SALES*) is expected to be positively related to PC adoption. With respect to Internet adoption, the costs of adopting are relatively modest once the computer has been adopted. Therefore, farm size (*SALES*) is not expected to influence Internet adoption. Because the information processing requirements of various farm enterprises differ, it is expected variables indicating the primary commodity enterprise (ENT_i) of the farm will be significant as a group in both the PC and Internet models.

The formality of the planning process on farms is expected to be positively related to PC and Internet adoption. The *MGMT* variable represents the number of written management plans used by the farm including written cash flow plans, business plans, risk management plans, long-term goals, succession plans, and marketing plans. The more intensive use of these planning tools indicates that the manager has dedicated increasing amounts of time to the strategic planning type activities. The PC and the Internet both offer significant advantages to these managers. The PC's usefulness is centered on turning on-farm data into useful information and in the process of identifying internal strengths and weaknesses. One of the most useful features of the Internet is the ease with which one can gather external information relevant to the farm business. Both types of information facilitate the planning process. Therefore, it is believed that more intensive use of management plans will increase the probability of both PC and Internet adoption.

The number of full-time hired, nonfamily farm employees (*EMPL*) is expected to be positively related to PC and Internet adoption. Farms with large numbers of employees must keep employment records. Likewise, the number of employees on the farm is a measure of the complexity the farming operation. The greater the number of employees, the greater the likelihood that the manager will have the time to conduct sophisticated analyses. This makes it more likely that she/he will utilize the benefits of computerized analysis and information seeking.

The involvement of the primary decision-maker with physical farm work (*PHYSICAL*) is expected to reduce the probability of both PC and Internet adoption. It is believed that managers not involved with physical labor are more inclined to be involved in a general manager's role. As such, managers not participating in physical labor are likely to be spending considerable time planning, gathering, and processing information. The PC and the Internet both offer these individuals considerable advantages in information processing and acquisition.

Respondents were also asked to indicate their agreement with several goal statements on a five-point Likert scale. The goals included in the adoption models were to maximize profitability (*MAXPROF*), to maximize production per unit of input (*MAXPROD*), and to increase the amount of free time for family and leisure (*FREE*). Both PC and Internet adoption are expected to be positively related to increasing agreement with the maximize profit, maximize production, and increase free time goals. It is expected that producers more focused on maximizing profit and production will perceive that the PC and Internet are tools

that can be used to achieve these goals. The PC allows the producer to more efficiently keep records and analyze production information. Likewise, the Internet can potentially offer the producer a great deal of convenience in acquiring information. In addition, the e-commerce strategies of many firms are focused on providing a more convenient way to make purchasing decisions.

Gloy and Akridge (1999) found that four market segments characterize commercial producers' attitudes toward the bundle of goods and services that might be provided by agricultural input suppliers. Membership in these buying segments is expected to influence PC and Internet adoption. Segment membership was accounted for with a set of indicator variables for Price buyers (*PRICE*), Convenience buyers (*CONV*), and Performance buyers (*PERF*) (Balance buyers were the omitted group). Because Price buyers were focused on purchasing from suppliers with the lowest priced products and services it is expected that they will find the Internet to be an extremely useful tool. Performance buyers were generally interested in product performance factors when selecting their input suppliers. It is expected that Performance buyers will be more likely to adopt both the PC and the Internet than members of the Convenience segment. Performance buyers should find the PC useful in analyzing the internal data generated by their operations and the Internet useful for accessing external production and marketing information. Because Convenience buyers were very reliant on local influences and local dealers, it is expected that they will be less likely to find the Internet useful. Balance buyers demanded a wide array of services and information and reasonable prices. These producers should find the Internet and PC quite useful and are expected to be more likely to adopt the PC and Internet than Convenience buyers.

5. Model

The probability of PC adoption was estimated with the logistic regression equation in (1).

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \sum_{i=1}^{4}\beta_i AGE_i + \sum_{i=5}^{10}\beta_i EDUC_i + \beta_{11}SALES + \sum_{i=12}^{16}\beta_i ENT_i + \beta_{17}MGMT + \beta_{18}EMPL + \beta_{19}PHYSICAL + \beta_{20}MAXPROF + \beta_{21}MAXPROD + \beta_{22}FREE + \sum_{i=23}^{25}\beta_i SEGMENT_i \quad (1)$$

where *ln* is the natural logarithm, p is the probability of adopting the computer; the $\beta_{i's}$ are parameters to be estimated; AGE_i is a series of four indicator variables for membership in an age category (less than 35 years old is the omitted group); $EDUC_i$ is a series of six indicator variables for membership in a specific education category (attended high school is the omitted group); *SALES* is total farm sales in dollars; ENT_i is a series of five indicator variables representing the farm commodity enterprise that generates the greatest sales (corn/soybeans is the omitted group); *MGMT* is an index which ranges from 0 to 6 and represents the level of written long-term business planning used by management (0 = few

written business plans, 6 = written management plans for most long-term business needs); *EMPL* is the number of full-time hired, nonfamily farm employees; *PHYSICAL* is an indicator variable indicating that the primary decision maker is involved in physical work (0 = no, 1 = yes); *MAXPROD*, *MAXPROF*, and *FREE* are the importance of each goal measured on a five-point Likert scale (1 = not at all important, 5 = very important); and $SEGMENT_i$ is a series of three indicator variables for buying segment membership (the Balance segment is omitted).

To model the probability of Internet adoption one must control for computer adoption. One possibility is to change the dependent variable in (1) to the natural logarithm of the odds of Internet use and estimate (1) with an additional indicator variable identifying computer owners and interaction effects between computer ownership and all the other variables in the model. An alternative is to replace the dependent variable with the natural logarithm of the odds of Internet adoption and control for computer ownership by only estimating the model within the population of commercial producers that had already adopted the PC. Because only 4% of the total respondents used the Internet without owning a computer, the latter approach was adopted.

6. Results

The logistic regression models were estimated with the logistic procedure in SAS V7 (SAS, 1989). The parameter estimates for the PC adoption model are given in Table 3. The chi-square statistic for the likelihood ratio test of the joint significance of all the nonintercept parameters is highly significant and the model correctly classifies 84% of the respondents. The statistical significance of the individual parameters was assessed with a Wald test statistic, which has a chi-square distribution. The significance of the groups of indicator variables for age, education, commodity enterprise, and market segment were assessed with likelihood ratio tests. The marginal change in probability was calculated as the product of the parameter estimate and the logistic density function evaluated at the mean of all the explanatory variables.[1]

Consistent with previous studies, age and education are important in explaining the probability of PC adoption. However, the probability of PC adoption does not generally fall as age increases. For instance, other things equal, respondents in the 35 to 44 and 45 to 54 year old age groups have a greater probability of adopting the PC than those under 35 years of age. Above 54 years of age, the probability of computer adoption falls. Levels of education above high school attendance increase the likelihood of computer adoption, with a master's level education and beyond greatly increasing the probability of adoption.

Several firm characteristics were important in explaining PC adoption. Total farm sales were positively related to adoption, but its marginal effect on the probability of adoption was quite small. With other variables held at their averages, an extremely large increase in total sales is required to increase the probability of adoption by one percentage. In other words, the relationship between size and computer adoption exists, but its practical effect on the probability of adoption is small. Increasing use of full-time hired, nonfamily employees increased the probability of PC adoption. In general, one would expect that a greater number

Table 3
Parameter estimates for personal computer adoption model

Variable	Description	Estimate	Wald χ-square statistic	χ-Square statistic for LRT	Marginal effects
Intercept		−1.7441	4.05**		
AGE1	35–44 years	0.3329	1.29	16.415***	0.0242
AGE2	45–54 years	0.1423	0.25		0.0104
AGE3	55–64 years	−0.3370	1.33		−0.0245
AGE4	65 and over	−0.7984	5.22**		−0.0581
EDUC1	high school graduate	0.9452	6.08**	36.893***	0.0688
EDUC2	graduate of 2 year college, trade program	1.6638	13.34***		0.1212
EDUC3	some 4 year college	1.7819	17.37***		0.1298
EDUC4	college graduate	1.5838	15.56***		0.1153
EDUC5	masters degree	3.2746	9.14***		0.2385
EDUC6	advanced degree work	2.5978	9.61***		0.1892
SALES	total farm sales	5.2E–7	8.99***		3.8E–08
Wheat/Barley	enterprise	−0.2817	1.06	1.762	−2.1E–02
Cotton	enterprise	−0.2527	0.72		−1.8E–02
Cattle	enterprise	−0.0947	0.12		−6.9E–03
Dairy	enterprise	−0.1463	0.31		−1.1E–02
Hogs	enterprise	0.0327	0.01		2.4E–03
MGMT	written management plans	0.1477	5.94**		1.1E–02
EMPL	hired nonfamily employees	0.2461	13.15***		0.0179
PHYSICAL	participation in physical labor	−0.8998	4.55**		−0.0655
MAXPROD	goal	0.0635	0.30		0.0046
MAXPROF	goal	0.2924	4.52**		0.0213
FREE	goal	0.1197	1.54		0.0087
Convenience	segment	−0.1560	0.46	1.074	−0.0114
Performance	segment	0.0102	0.31		0.0007
Price	segment	0.1288	0.00		0.0094
Likelihood ratio test statistic for model significance				176.74***	
Percent of observations classified correctly				84%	

* Indicates significance at the 0.10 level; ** indicates significance at the 0.05 level; *** indicates significance at the 0.01 level.

of employees increases the strain on manual record keeping and encourages PC adoption. It is also likely that increasing the number of employees frees time for the primary decision-maker to undertake detailed analyses for which the PC is extremely useful. In addition, increasing numbers of employees is possibly related to the sophistication and complexity of the farm business. The positive significant coefficient on the *MGMT* variable indicates that increasing use of written business plans increases the probability of PC adoption. This suggests that managers making use of sophisticated planning techniques are likely to find the computer more useful than producers using few written plans.

Of the three goals considered, only the maximize profitability goal (*MAXPROF*) was important in explaining PC adoption. It is possible that farms focused on profit maximization can see clear value in the organizational and information processing benefits of the computer. The lack of a relationship between the maximize production goal (*MAXPROD*) and PC adoption was surprising as one would expect that producers with a production focus would

be more interested in tracking past production and undertaking computerized analyses designed to optimize production. Likewise, the importance of the goal of increasing the amount of free time for family and leisure (*FREE*) was not important in explaining PC adoption. The lack of importance of these goals suggests that these motivations are not sufficient for PC adoption. Perhaps producers do not see the PC as tool that facilitates achieving these goals.

The farm's primary commodity enterprise was not significant in explaining PC adoption, indicating that other things equal, the six primary commodity enterprise classes had roughly the same likelihood of PC adoption. Buying segment membership was not important in determining the probability of PC adoption. This provides some evidence that the characteristics of the bundle of goods and services demanded by farmers does not differ dramatically among PC adopters and nonadopters. This suggests that the motivations encouraging adoption are different from those motivating product and service purchase decisions.

7. Internet use

The results of the Internet model are presented in Table 4. Again, the likelihood ratio test statistic for the joint explanatory power of the independent variables was highly significant. The model correctly classified 61% of the respondents. Several strong relationships emerged between the explanatory variables and Internet adoption.

As in the PC adoption model, personal characteristics were important in explaining the probability of Internet use. Unlike the PC model, the probability of Internet use declined with all age levels. The marginal effects of the age variables were also large. For instance, at mean variable levels, individuals over 65 years of age were 27% less likely to use the Internet than those under 35 years of age. Because these producers have already adopted the PC, this result strongly suggests that the Internet is viewed as a much different technology than the computer and that age related factors are limiting Internet adoption. These factors likely include learning how to use the new technology as well as differing information needs. Older producers may find the information gathering aspects of the Internet less useful than younger producers. It also indicates that even after producers have adopted the PC, age is extremely important in determining Internet adoption.

Although significant as a group, significant differences in the probability of Internet adoption associated with education did not emerge until the individual reached the masters level (and above). These higher levels of education also had large effects on the probability of adoption. Other things equal, greater levels of education were required to see the value of the Internet. Again, to the extent that information gathering is one of the Internet's most useful features, it is possible that the information needs of more educated producers are different from their less educated counterparts. Likewise, this result might stem from an ability to learn to make use of new technologies.

As expected, there is not a strong relationship between farm size (*SALES*) and Internet use. There are strong relationships between variables such as *MGMT, EMPL,* and *PHYSICAL*. The strong relationship between the *MGMT* variable and the probability of Internet use indicates that other things equal, an increase in the intensity of farm planning increases the likelihood of Internet use. This result is reasonable given that the

Table 4
Parameter estimates for Internet adoption model

Variable	Description	Estimate	Wald χ-square statistic	χ-Square statistic for LRT	Marginal effects
Intercept		1.3015	2.61		
AGE1	35–44 years	−0.3491	2.46	17.301***	−0.0870
AGE2	45–54 years	−0.4696	4.68*		−0.1170
AGE3	55–64 years	−0.8150	11.47***		−0.2031
AGE4	65 and over	−1.0871	11.28***		−0.2709
EDUC1	high school graduate	−0.2074	0.20	46.844***	−0.0517
EDUC2	graduate of 2 year college, trade program	−0.0323	0.00		−0.0080
EDUC3	some 4 year college	−0.1146	0.06		−0.0286
EDUC4	college graduate	0.6395	1.85		0.1594
EDUC5	masters degree	1.4972	6.35**		0.3731
EDUC6	advanced degree work	0.8574	2.03		0.2136
SALES	total farm sales	−2.5E–8	0.40		−6.2E–09
Wheat/Barley	enterprise	0.1103	0.22	2.704	2.8E–02
Cotton	enterprise	0.1081	0.24		2.7E–02
Cattle	enterprise	−0.0358	0.03		−8.9E–03
Dairy	enterprise	−0.0301	0.02		−7.5E–03
Hogs	enterprise	−0.2397	1.37		−6.0E–02
MGMT	written management plans	0.1437	11.24***		−3.6E–02
EMPL	hired nonfamily employees	0.0432	5.83**		0.0108
PHYSICAL	participation in physical labor	−0.8886	11.65***		−0.2214
MAXPROD	goal	0.0422	0.19		0.0105
MAXPROF	goal	−0.1629	1.61		−0.0406
FREE	goal	0.0710	0.85		0.0177
Convenience	segment	−0.0948	0.24	2.831	−0.0236
Performance	segment	−0.3053	2.69		−0.0761
Price	segment	−0.0263	0.02		−0.0066
Likelihood ratio test statistic for model significance				131.37***	
Percent of observations classified correctly				61%	

* Indicates significance at the 0.10 level; ** indicates significance at the 0.05 level; and *** indicates significance at the 0.01 level.

two most common uses of the Internet were for gathering product and price information. The participation of the manager in farm physical labor was negatively related to adoption. This is likely indicative of the amount of time the manager spends gathering information for the farm business. Likewise, the number of employees (*EMPL*) on the farm was positively related to adoption. Together these results suggest that the manager's role in the farm business is important in determining Internet adoption. As the manager hires more employees, they have more time for analyses and information gathering, and when the manager does not participate in physical labor at all, it again greatly increases the time that the manager has for these purposes.

None of the goal statements were significantly related to Internet use. This indicates that at this time, producers have yet to perceive a clear relationship between Internet use and maximizing profit, maximizing production, or increasing the amount of free time available for family or leisure. The lack of the existence of a relationship between the increase free

time (*FREE*) goal indicates that producers do not perceive that the Internet is able to reduce the amount of time that they spend managing their business. Likewise, although buying segments exist in this market, segment membership was not significant in explaining Internet adoption. This provides some evidence that the farmers using the Internet are not the most price conscious or performance minded producers. As with the case of PC adoption, this result suggests that the motivations governing product and service purchase decisions are somewhat different than adoption motives.

8. Conclusions

This paper examined the adoption of two related technologies, the personal computer and the Internet. Age and education were found to be important factors in the adoption of both technologies. The importance of these factors is believed to be related in part to the amount of learning required to implement the technologies and the learning required to make the technologies useful. After controlling for PC adoption, the continuing importance of these factors in Internet adoption suggests that producers perceive the Internet to be quite different from the PC.

Managers using detailed management plans were much more likely to adopt the Internet. This relationship suggests that producers are likely searching for information that facilitates their planning process on the Internet. The existence of a strong relationship between the maximize profit goal and computer adoption indicates that farm managers seem to perceive the PC as a profit maximizing input. On the other hand, Internet adoption was not strongly related to the maximize profit, maximize production, or increase free time farm goals. This implies that producers are unsure as to how the Internet might be used to achieve their goals.

The farms in this study were all large farms, each having at least one commodity enterprise that generated annual sales in excess of $100,000. The lack of a relationship between total farm sales and Internet adoption should be taken in the context of the sample. However, the importance of personal characteristics and general lack of importance of many business characteristics such as size, enterprise type, and customer segment membership in the Internet adoption model is interesting. Marketers are reminded that although these businesses are large and sophisticated, adoption decisions are strongly influenced by the personal characteristics of the primary decision-maker.

The ability to access the Internet, cost of accessing the Internet, and the content of the Internet are also important considerations that impact Internet use. These factors appear to be changing quite rapidly. Internet availability in rural areas appears to be increasing, and the costs of accessing the Internet are falling as more competitors offer access. It is believed that increased availability and lower access costs will work to encourage adoption. Similarly, the amount of agricultural content on the Internet is also rapidly growing and more firms are offering products for sale on the Internet. These developments are expected to draw more producers to the Internet. Despite these changes, it is likely that personal characteristics of

commercial producers such as age and education will continue to be important in explaining Internet adoption.

The Internet presents managers with different features than the PC. The most obvious of these is a tool with which to gather external information rather than to simply process internal information. The Internet also provides a communication medium that differs from the uses of the PC. Firms wishing to communicate and transact business with producers via the Internet must realize that their audience is different from ordinary farm PC users. It is also likely that programs designed to help the producer integrate the Internet into farm management activities would be of value to many commercial producers.

Notes

1. Greene (1997) demonstrates that this slope approximation can be relatively good even in the case of indicator variables. Because there are four sets of indicator variables the marginal effects of the indicator variable would have to be calculated for each of the possible cases, for example, under 35 with high school education with wheat/barley primary enterprise and price segment member, under 35 with high school education with wheat/barley primary enterprise and performance segment member, and so forth.

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Appendix

The farms in the sample were identified from a proprietary database that contained information on farm size, enterprise type, and location. Based on the desired response rates, 10,500 surveys were mailed to farms believed to have sales in excess of $100,000. The six enterprises targeted were corn/soybeans, wheat/barley, cotton, dairy, cattle, and hogs. Geographic targeting was accomplished by ranking production/inventory of each of the six commodities by state. The smallest number of states required to account for 75% of production/inventory of each commodity were then identified. Finally, individual producers located in these states were identified for sampling. A complete discussion of the survey design, data collection procedure, and response can be found in Akridge et al. (2000). To address nonresponse bias, the respondent demographics were compared to Census of Agriculture data. The response by geographic and enterprise classes were evaluated with respect to prior expectations and found to be very similar. Producers in enterprise-state-farm size cells with low response rates were identified and additional calls were made to individuals in these cells to encourage response. Appendix Table 1 shows the percentage

Appendix Table 1
Characteristics of the commercial producer sample

Variable	Percent of sample
Age:	
under 35 years	12
35 to 44 years	23
45 to 54 years	30
55 to 64 years	23
65 years and over	12
Education:	
attended high school	3
high school graduate	32
graduate of 2 year college or trade program	12
some 4 year college	17
college graduate	30
masters degree	4
advanced graduate work	3
Farm Size: annual total farm sales in dollars (mean sales)	1,208,003*
Farms whose primary enterprise was:	
corn/soybeans	27
cotton	14
wheat/barley	12
cattle	17
hogs	15
dairy	16
Number of written business plans—cash flow plans, business plans, risk management plans, long-term goals, succession plans, and marketing plans (range is from 0 to 6)	1.8*
Number of full-time hired, nonfamily employees	2.8*
Importance of various goals (measured on a five-point Likert scale 1 = not at all important, 5 = very important)	
Maximize profit	4.7*
Maximize production per unit of input	4.4*
Increase amount of free time for family and leisure	4.0*
Customer Segment: membership in buying segment	
balance	47
convenience	15
performance	16
price	21

* Sample mean.

of the sample in various categories or the sample mean for the variables included in the adoption models.

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