Drivers of Internet Adoption on Large U.S. Farms and Implications for Agribusiness

ABSTRACT: Internet use is studied within a sample of large U.S. farms. Nearly half of the respondents had adopted the Internet. Factors such as age and education strongly influence Internet adoption. Likewise, strong relationships exist between Internet adoption, the sophistication of farm management practices employed, and the complexity of the farm business. Producer use of the Internet for information gathering and purchasing also varies with the age and education of the producer.

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The Internet has the potential to change the way many agribusinesses conduct business. Agribusinesses can use the Internet to communicate with current customers and suppliers, establish relationships with new customers, trade or make transactions with customers or suppliers, quickly gather and disseminate information, and much more. Agribusiness firms are exploring applications of the Internet for virtually every internal business process and every external firm relationship. As a result, the Internet in some way has or will in the near future impact the business strategy of all agribusinesses.

Commercial farms, farms with sales in excess of $100,000, represent a priority market segment for many agribusinesses. In 1997, these farms accounted for 18 percent of US farms, produced 87 percent of the market value of agricultural products sold, and generated 84 percent of the production expenses associated with the farm sector (Table 50, 1997 U.S. Census of Agriculture, USDA-NASS). According to a 1999 National Agricultural Statistics Service (NASS) report, 68 percent of these farms had computer access and 43 percent had Internet access. In order for agribusinesses to develop effective Internet strategies, it is important to understand how these key customers are using the Internet, what factors encourage or discourage Internet adoption by commercial farms, and whether there are factors that distinguish between producers using the Internet to gather information from those using the Internet to purchase products. This knowledge will increase agribusiness's understanding of the characteristics, motivations, and needs of producers adopting this technology. By combining this understanding with a supplier's knowledge of the characteristics of their target market, agricultural marketers can increase their chances of developing successful Internet strategies.

This paper uses logistic regression analysis to investigate the factors that influence the likelihood that a producer adopts the Internet, uses the Internet to gather information, and uses the Internet to make purchases. When modeling Internet adoption, it is crucial to account for the sequential nature of the PC – Internet adoption process. From this perspective, producers adopt the PC and then later adopt the Internet. It is possible that the PC – Internet adoption is a joint decision. However, this is unlikely given that previous studies show that 70 percent of the commercial producer market was using a computer in 1993 (Center for Agricultural Business, 1993).

The Factors Influencing Internet Use

Numerous studies have explored computer adoption by farmers, but few have explored Internet adoption. By controlling for PC adoption it is possible to better understand the factors that influence Internet adoption. Here, the factors influencing computer ownership are controlled for by estimating the Internet adoption model within the population of commercial producers that had already adopted the PC.

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). Researchers studying PC adoption by farmers have found both personal and business characteristics to be related to PC adoption (Amponsah, 1995; Ortmann, Patrick, and Musser, 1994; Huffman and Mercier, 1991; Batte, Jones, and Schnitkey, 1990; Jarvis, 1990; Putler and Zilberman, 1988). Some of the personal characteristics consistently found to be related to PC adoption include level of education and age. Business characteristics that appear to influence PC adoption include farm size, farm complexity, and the presence of specific enterprises. It is expected that after controlling for PC adoption many of these factors will also influence Internet adoption.

Age (AGE_i) and education level ($EDUC_i$) of the farm's primary decision-maker are the personal characteristics included in the Internet adoption, information gathering, and purchasing models. 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 learning process required to use the PC does not prepare the producer to use the Internet. Producers are likely to view the Internet as a new and different technology. To the extent that age captures factors such as the willingness to adopt new technologies, it is expected that age will be negatively related to Internet adoption, using the Internet to gather information, and using the Internet to make purchases. It is also likely that younger producers have different information needs than older producers. This suggests that increasing age will reduce the probability of Internet adoption and using the Internet for information gathering.

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 access. 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, using the Internet to gather information, and using the Internet to make purchases.

After adopting the PC, the costs of adopting the Internet are relatively small. This would suggest that size (*SALES*) should not influence Internet adoption. However, to the extent that farm size is related to the sophistication of the business, farm size should be positively related to Internet adoption. Likewise, if information is more valuable on larger farms one would expect that farm size is positively related to Internet adoption and use. Because larger farms make more purchases it is expected that farm size will be positively related to the probability that the farm

uses the Internet to make purchases. Because the information processing requirements of various farm enterprises differ, it is expected variables indicating the primary enterprise (ENT_i) of the farm will be significant as a group in the Internet adoption, information gathering, and purchasing models.

The formality of the planning process on farms is expected to be positively related the probability of Internet adoption and probability of using the Internet for information gathering purposes. 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 formal planning tools indicates that the manager has dedicated increasing amounts of time to the strategic dimensions of management. One of the most useful features of the Internet is the ease with which one can gather external information relevant to the farm business. It is also likely that farms with more active management will be more likely to use the Internet to make purchases.

The number of full-time, hired farm employees (*EMPL*) is expected to be positively related to Internet adoption, information gathering, and purchasing. The number of employees on the farm is a measure of the level of complexity of the farm business. The greater the number of employees, the more complex the business. The more complex the farm business, the more likely the farm will seek the convenience of using the Internet to gather information and to make purchases.

The involvement of the primary decision-maker with physical farm work (*PHYSICAL*) is expected to reduce the probability of Internet adoption, using the Internet to gather information, and using the Internet to make purchases. 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 spend considerable time planning, gathering, and processing information. The Internet offers these individuals considerable advantages in information acquisition and convenience in purchasing.

Respondents were also asked to indicate their agreement with the importance of several goal statements on a 5 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*). Internet adoption, using the Internet to gather information, and using the Internet to make purchases is expected to be positively related to increasing agreement with the importance of 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 Internet is a tool that they can use to achieve these goals. 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 (forthcoming) found that four market segments characterize commercial producers' attitudes toward the bundle of products, services, and information that might be provided by agricultural input suppliers. Membership in these buying segments is expected to influence Internet adoption and use. 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 and will be more likely to use the Internet to gather information and make purchases. 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 the Internet and use the Internet to gather information. However, it is expected that Performance buyers will be less likely to use the Internet to make purchases. 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 and will be the least likely to use the Internet to gather information or make purchases.

Data

The data used to examine Internet adoption and use 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. The initial survey instrument was pre-tested with farmers in February 1998. After modification, the final survey instrument and 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 non-respondents 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 percent. Of the 10,500 surveys sent, 1,742 usable questionnaires were returned, for a response rate of 16.59 percent. Corn/soybean growers accounted for the largest number of respondents and wheat/barley growers the fewest. Nearly 61 percent of the respondents had one enterprise that generated sales of at least $500,000 and the remainder had

one enterprise with sales of at least $100,000. A thorough description of the sampling procedure can be found in Akridge, et al. (forthcoming) or Gloy (1999).

Respondents were asked several questions related to their farm's use the Internet. Table 1 shows that nearly half of the respondents indicated that they are using the Internet. The most popular uses of the Internet are obtaining product-related information (30 percent of respondents) and obtaining marketing related information (26 percent of respondents). Only 5 percent of the respondents had used the Internet to make a purchase, and 2 percent 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.

Model

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

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

where *ln* is the natural logarithm, *p* is the probability of adopting the Internet; 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 enterprise which generates the greatest sales (corn/soybean is the omitted group); *MGMT* is an index which ranges from 0 to 7 and represents the use of written business planning tools by management (0 = few written business plans, 7 = written management plans for most long-term

business needs); *EMPL* is the number of full-time hired, non-family 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 5 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).

Two additional models were developed to investigate the relationship between specific uses of the Internet and the independent variables. The variable *INFO* was created to identify producers which had used the Internet to obtain product related information and/or price related information and/or management related information (1 = yes, 0 = no). Similarly, the variable *PURCH* was created to identify producers which indicated that they had used the Internet to place orders (1 = yes, 0 = no). The probability of using the Internet for each of these purposes was estimated with the appropriate dependent variable and the same independent variables as (1).

Results

The logistic regression models were estimated with the logistic procedure in SAS V7 (SAS, 1989). The parameter estimates for the Internet adoption model are given in Table 2. The likelihood ratio test statistic for the joint explanatory power of the independent variables is highly significant. The model correctly classifies 61 percent of the respondents. Several strong relationships emerge between the explanatory variables and Internet adoption.

Personal characteristics are important in explaining the probability of Internet use. The probability of Internet use declines with all age levels. The marginal effects of the age variables are also large. For instance, at mean variable levels, individuals over 65 years of age are 27 percent less likely to use the Internet than those under 35 years of age. This indicates that age is extremely important in determining Internet adoption. Further, this relationship might indicate

that different age groups have different attitudes toward technology, different information needs, and different experiences with technology.

Although significant as a group, significant differences in the probability of Internet adoption associated with education do not emerge until the individual reaches the masters (and above) education level. These higher levels of education also have large effects on the probability of adoption. This indicates that other things equal, greater levels of education are required to see the value of the Internet.

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 and managerial sophistication increases the likelihood of Internet use. This result is reasonable given that the two most common uses of the Internet are 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 is 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, the sophistication of the farm business increases, and when the manager does not participate in physical labor at all, it again greatly increases the likelihood of adoption. These variables are also likely related to the complexity of the farm business and the sophistication of its management. If this is true, the more complex the business and the more sophisticated the management, the more likely that the farm will adopt the Internet.

None of the goal statements are significantly related to Internet use. This indicates that at this time producers have yet to understand the specific role that the Internet might play in their businesses. The lack of the existence of a relationship between the increase free time (*FREE*) goal and Internet adoption 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 is not significant in explaining Internet adoption. This provides some evidence that the farmers adopting the Internet are not the most price conscious or performance minded producers.

The results for both the information gathering and purchasing models should be interpreted with caution. Because relatively small proportions of the respondents are using the Internet for these specific purposes, the relationships need further investigation. Table 3 presents the parameter estimates for the information gathering model. The results show that age and education are important in explaining the probability of using the Internet to gather information. Both variables also have relatively large marginal effects. The education variables show that significant differences do not emerge until education reaches the level of college graduate. Again, the sales and enterprise variables show that information gatherers are <u>not</u> more likely to be found in any specific farm enterprise or among large farms. The management, employee, and physical labor variables are significant and have the anticipated signs. In this case, buying segment membership is significant and indicates that the Price and Balance segment members are more likely to be using the Internet for information gathering purposes than the Performance and Convenience segment members. This might indicate that price sensitive buyers are using the Internet to gather price information and using this in their supplier negotiations. Likewise, Balance buyers are characterized as buyers who look for value in the total

product/service/information bundle and they too may be using the Internet as a bargaining tool, or simply as an efficient source of information.

Table 4 presents the parameter estimates for the Internet purchasing model. The results show that only the age and education variables are significant in explaining the probability of using the Internet to make purchases. The effect of age in this model is different than in the general Internet adoption model where the probability of adoption declined with all age levels. Here, the probability of using the Internet to make purchases increases until the producer reaches the 55 year age category, indicating that producers in the 35 to 54 year age range have roughly the same probability of purchasing on the Internet as producers under 35 years of age. Education is also important in explaining Internet purchasing. Interestingly, it is the least educated producers who have the largest probability of using the intent to make purchases. Again, with only 5 percent of the sample using the Internet to make purchases, these results must be viewed as indicative of the very earliest users of the Internet for this purpose.

Conclusions

This paper examined the adoption and use of the Internet for information gathering and purchasing. The demographic variables, age and education, were among the most important factors in explaining all three phenomena. The importance of these factors is believed to be related to several more complex issues. The age variable could account for many factors such as attitudes of different generations toward technology and differing information needs of producers at different stages of their careers. The education variable most likely represents different ability and eagerness to learn to use new technologies as well as the overall ability to make the information gathered from the Internet useful.

The farms in this study were all large farms, each having at least one enterprise which generated sales in excess of $100,000. The lack of a relationship between total farm sales and Internet adoption and use 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 which impact Internet use. These factors are 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 Internet 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. In spite of these changes, it is likely that personal characteristics of the farmers such as age and education will continue to be important in explaining Internet adoption.

At the time the survey used in this analysis was conducted, the Internet was less well developed and using the Internet to make purchases was a relatively new opportunity for farmers. In addition, our data cannot discriminate between the types of purchases respondents were making on the Internet. Thus, it is important that the results are interpreted with some caution. However, the results suggest that there may be differences among producers purchasing products on the Internet and those simply using the Internet to gather information. Although

both types of users tend to be younger, there appear to be slight differences in the relationship between this characteristic and the particular uses of the Internet.

As suppliers continue to make more sophisticated offerings on the Internet, it is important that they continue to monitor the characteristics and needs of the producers taking advantage of these offerings. Many firms' web-sites offer farmers both information and the ability to make purchases. Firms will need to take advantage of the information collection abilities of the Internet to detect how different producers are using the Internet and then tailor their Internet offerings and capabilities accordingly.

Table 1. Internet use by large U.S. farms.

Internet Use	Percent Using
Do not use Internet	51%
Do not use Internet for farm business purposes	5%
Obtain product related information	30%
Obtain market related information	26%
Obtain management information	16%
Place orders for products	5%
Sell or market my products	2%
Participate in a "chat" group	5%

*N=1,662

Table 2. Parameter estimates for Internet adoption model.

Variable	Description	Estimate	Wald Chi-Square Statistic	Chi-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 non-family 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

Table 3. Parameter estimates for information gathering model.

Variable	Description	Estimate	Wald Chi-Square Statistic	Chi-Square Statistic for LRT	Marginal Effects
Intercept		0.4060	0.24		
AGE1	35 – 44 years	-0.3785	3.02*	19.568***	-0.0927
AGE2	45 – 54 years	-0.6048	8.15***		-0.1482
AGE3	55 – 64 years	-0.8235	11.97***		-0.2017
AGE4	65 and over	-1.2066	13.18***		-0.2956
EDUC1	High school graduate	0.1315	0.07	59.965***	0.0322
EDUC2	Graduate of 2 year college, trade program	0.3571	0.44		0.0875
EDUC3	Some 4 year college	0.3683	0.50		0.0902
EDUC4	College graduate	1.0413	4.10**		0.2551
EDUC5	Masters degree	2.3010	13.35***		0.5637
EDUC6	Advanced degree work	1.1241	3.28*		0.2754
SALES	Total farm sales	-1.1E-08	0.08		-2.8E-09
Wheat/Barley	Enterprise	1.2E-01	0.25	4.827	2.9E-02
Cotton	Enterprise	9.5E-02	0.18		2.3E-02
Cattle	Enterprise	-1.4E-01	0.48		-3.6E-02
Dairy	Enterprise	-1.8E-01	0.73		-4.4E-02
Hogs	Enterprise	-3.2E-01	2.40		-7.9E-02
MGMT	Written management plans	1.2E-01	8.32***		3.0E-02
EMPL	Hired non-family employees	0.0367	5.33**		0.0090
PHYSICAL	Participation in physical labor	-0.6050	6.15**		-0.1482
MAXPROD	Goal	0.1452	2.19		0.0356
MAXPROF	Goal	-0.1828	2.00		-0.0448
FREE	Goal	-0.0080	0.01		-0.0020
Convenience	Segment	-0.2251	1.30	6.144*	-0.0551
Performance	Segment	-0.4226	4.94**		-0.1035
Price	Segment	0.0091	0.01		0.0022
Likelihood Ratio Test Statistic for Model Significance				143.01***	
Percent of Observations Classified Correctly				62%	

*indicates significance at the 0.10 level, **indicates significance at the 0.05 level, and ***indicates significance at the 0.01 level

Table 4. Parameter estimates for purchasing model.

Variable	Description	Estimate	Wald Chi-Square Statistic	Chi-Square Statistic for LRT	Marginal Effects
Intercept		-0.8738	0.33		
AGE1	35 – 44 years	0.2752	0.44	8.90**	0.0104
AGE2	45 – 54 years	0.1496	0.14		0.0057
AGE3	55 – 64 years	-0.6803	1.74		-0.0258
AGE4	65 and over	-1.7036	2.36		-0.0646
EDUC1	High school graduate	-1.9032	4.82**	11.39**	-0.0721
EDUC2	Graduate of 2 year college, trade program	-1.3218	2.23		-0.0501
EDUC3	Some 4 year college	-1.2548	2.15		-0.0476
EDUC4	College graduate	-0.8671	1.12		-0.0329
EDUC5	Masters degree	-0.3643	0.15		-0.0138
EDUC6	Advanced degree work	-0.8809	0.72		-0.0334
SALES	Total farm sales	0.0000	0.90		-2.3E-09
Wheat/Barley	Enterprise	-0.3399	0.47	2.61	-1.3E-02
Cotton	Enterprise	-0.3981	0.75		-1.5E-02
Cattle	Enterprise	-0.5284	1.32		-2.0E-02
Dairy	Enterprise	0.0841	0.05		3.2E-03
Hogs	Enterprise	-0.0828	0.05		-3.1E-03
MGMT	Written management plans	0.0887	1.21		3.4E-03
EMPL	Hired non-family employees	0.0488	10.13***		0.0019
PHYSICAL	Participation in physical labor	-0.2156	0.22		-0.0082
MAXPROD	Goal	0.0552	0.08		0.0021
MAXPROF	Goal	-0.2375	0.91		-0.0090
FREE	Goal	0.0112	0.01		0.0004
Convenience	Segment	0.5478	2.10	2.657	0.0208
Performance	Segment	0.4052	1.28		0.0154
Price	Segment	0.1123	0.10		0.0043
Likelihood Ratio Test Statistic for Model Significance				48.20***	
Percent of Observations Classified Correctly				94%	

*indicates significance at the 0.10 level, **indicates significance at the 0.05 level, and ***indicates significance at the 0.01 level

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