Record-Keeping Technology Adoption among Dairy Farmers

By Elisabeth Grisham and Jeffrey Gillespie

Abstract

Louisiana farmers were surveyed to determine their adoption of information and record-keeping technologies, including the Internet, Dairy Herd Improvement Association membership, use of financial measures, and frequency of use of computerized records. Factors influencing adoption included having a family successor, overall technology adoption propensity, diversification, off-farm income, college degree, and others.

A number of record-keeping technologies are available to U.S. dairy farmers, including but not limited to those provided by the Dairy Herd Improvement Association (DHIA), various Internet sources, and other computerized systems. Farm management experts frequently cite the importance of good record keeping in improving farm efficiency and profitability. The rapid drop in U.S. dairy farm numbers along with increased milk production and relatively stagnant nominal milk prices over recent decades suggests that surviving farms must continue to improve their business and financial management in order to remain profitable. Identifying the types of financial and production records producers are keeping and the types of producers who are keeping them is beneficial in designing extension programs to assist the remaining producers. This study examines adoption rates of financial and production record-keeping technologies by Louisiana dairy farmers.

Computerized farm record-keeping systems are relatively easy to adopt since computers and software have become increasingly available. With adequate effort to learn how to use computer technologies, they can be used by most farmers producing any commodity or mix of commodities. Blank spreadsheet programs can be used for more than just accounting information, but it takes significant time and effort to design spreadsheets that meet all of the needs of a farm business. Pre-designed bookkeeping software such as Quicken and QuickBooks are set up for accounting functions such as entering checks, paying bills, and generating financial statements. Such software, however, is generally more expensive than basic spreadsheets, requires significant training, and the accounts, suppliers, customers, and vendors must be set up before use.


Elisabeth Grisham and Jeffrey Gillespie are respectively, former graduate student and Martin D. Woodin Endowed Professor, Department of Agricultural Economics and Agribusiness, Louisiana State University Agricultural Center.

The types of production record-keeping systems are basic spreadsheets, DHIA records, milk tickets, and hand-written records. The DHIA is a program through which farmers pay a fee for technicians to weigh and test for quantity and quality. The DHIA also tracks the genetic history of cattle and can predict the yearly production of offspring of individual cows and bulls. Additionally, DHIA can track when cows are vaccinated, dried-up, freshened, bred, and when they calve. Milk tickets are receipts that are mailed out to farmers periodically to inform them of how much milk they shipped during the period. Some farmers keep production figures, cow medications, and breeding records in a notebook and refer back to them as needed. Other farmers retain most information via memory.

Previous Literature

Rogers (1962) defined technology adoption as "the mental process an individual passes from first hearing about an innovation to final adoption." Final adoption at the individual farmer level is defined by Feder et al., (1985) as "the degree of use of a new technology in long run equilibrium when the farmer has full information about the new technology and its potential." The shape of the adoption curve is generally an S-shaped logistic curve, where adoption is slow at first, increasing at an increasing rate, then increasing at a decreasing rate, and finally leveling off (Hoag, Ascough, & Frasier, 1999).

A number of factors have been shown to have positive influences on the probability of technology adoption: formal education (Rahelizatovo & Gillespie, 2004; Rahm & Huffman, 1984; Saha & Schwart, 1994; Barrett et al, 2004; Barham et al., 2004; Zepeda, 1994; Shields et al., 1993), farm size (Rahelizatovo & Gillespie, 2004; Rahm & Huffman, 1984; Saha & Schwart, 1994; Barrett et al, 2004; Barham et al., 2004; Zepeda, 1994; Shields et al., 1993; Gillespie et al., 2004; Saha & Butler, 1995), yield (milk/cow/year or bushels/acre) (Rahelizatovo & Gillespie, 2004; Zepeda, 1994; Saha & Butler, 1995), and positive prior technology adoption (Rahelizatovo & Gillespie, 2004; Barham et al., 2004; Zepeda, 1994). Age has been found to have a negative relationship with technology adoption. Zepeda (1994) found that with experience initially records were used more, with adoption then leveling off and eventually declining. Other factors found to influence technology adoption include farm diversification (Gillespie et al., 2004), debt-asset ratio (Gillespie et al., 2004), DHIA usage (Rahelizatovo & Gillespie, 2004), conferences and extension use (Rahm & Huffman, 1984; Barrett et al, 2004; Zepeda, 1994), experience (Rahm & Huffman, 1984; Zepeda, 1994), plans to expand (Saha et al., 1994), farmer management ability and technology use by peers (Barham et al., 2004), capital availability (Shields et al., 1993), and land tenure (Rahelizatovo & Gillespie, 2004; Rahm & Huffman, 1984; Zepeda, 1994).

Computer Adoption

While work has been conducted on technology adoption by dairy producers, studies are lacking regarding computerized record-keeping systems among southeastern dairy farmers. Iddings and Apps (1990) found that the complexity of the farm increased the need for computers among Wisconsin and Kansas farmers, but that older farmers were less likely to adopt computers. Hoag et al. (1999) found that among Great Plains farmers, experience reduced the probability of computer adoption. Putler and Zilberman (1988) found that age affected computer adoption among Tulare County, California, farmers, with adoption increasing up to age 40 and then decreasing. Farm size positively influenced the probability of adopting computer technology among Great Plains and North Carolina farmers (Hoag et al., 1999; Amponsah, 1995). Putler and Zilberman (1988) also found larger farms had higher rates of adoption, but the influence diminished with size. Increased education has been found to lead to greater computer adoption (Putler & Zilberman, 1988; Amponsah, 1995; Gloy & Akridge, 2000).

Other factors found to influence computer technology adoption by farmers include the degree of external support (Iddings & Apps, 1990), network of computer users the farmer is familiar with (Iddings & Apps, 1990), ownership of a non-farm business (Dove, 2004), off farm employment (Dove, 2004), peer computer use (Dove, 2004), management skills (Jarvis, 1990), computer familiarity (Jarvis, 1990), land tenure (Hoag et al., 1999) and income and formal farm record-keeping systems (Amponsah, 1995).

Data and Methods

This study uses primary data gathered from personal interviews with Louisiana dairy farmers. A list of dairy farmers was obtained, including the entire population of 293 Louisiana dairy farmers as of July 2005. Over a two-month period, groups of 50 farmers each were sent letters requesting an interview and explaining the purpose of the study. A few days after the letter was expected to have arrived, each was phoned and asked for an on-farm interview. When farmers agreed to the interview, a time was scheduled for the approximately 1-1/2 hour interview.

Of the 293 farmers, 50 agreed while 68 did not agree to the survey. Thirty-three were out of the dairy business, 14 did not have a listed phone number, 27 had incorrect or disconnected phone numbers, and 101 never answered the phone when called repeatedly (three days in a row, approximately four times each day).

Seven analyses were used to examine the types of dairy farmers having experience with computerized information and record-keeping systems, as well as general use of financial statements. Logit analysis, described in Greene (2000, p. 215) was used to determine factors influencing whether computerized record-keeping systems were used and whether farmers had experience with using the Internet. The logit model is suitable for the analysis of binary responses where the objective is to determine the influence of factors on the probability of adoption. In this study, "yes/no" questions were asked regarding whether the farmer utilized a computerized record-keeping system and whether he had experience with using the Internet.

Ordered probit analysis, described in Greene (2000, p. 876), was conducted to determine factors influencing the frequency of updating farm record systems and farmers' perceived usefulness of their computer systems. The ordered probit is suitable for the analysis of responses that are inherently ordinal in nature. For example, the question regarding updating of farm record-keeping systems was worded as, "How often do you update your record-keeping system?" Choices were, "annually," "monthly," "weekly," and "daily." (Note that the intervals among the responses may vary and may be ordered from "most" to "least.") The question regarding perceived usefulness of the computer system was worded as, "How useful do you perceive the computer system to be for your farm business?" Choices were "not at all useful," "of limited usefulness," "moderately useful," and "very useful."

Negative binomial regression analysis, described in Greene (2000, p. 887), was performed to determine the influence of factors on the number of financial measures farmers used to track their financial performance, and how many different financial statements were generated to measure their financial performance. Negative binomial regression analysis is useful in cases where the response is a numeric count of a phenomenon, such as used by Rahelizatovo and Gillespie (2004). Financial measures assessed were: profitability, solvency, repayment capacity, liquidity, and financial efficiency, for a highest potential count of five. Financial statements were: net income, balance sheet, cash flow, and owner's equity, for a highest potential count of four.

A double hurdle model, which consists of a probit in the first stage and a truncated regression in the second, was used to determine among those who were using DHIA to keep their production records which factors affected the hours per week spent analyzing the DHIA output. The double hurdle model is described in Dong and Saha (1998) with the first stage probit useful in cases of a binary dependent variable (similar in many respects to the logit model), and the second stage is truncated, such as at 0 in the case where no time is spent analyzing DHIA output.

Explanatory Variables

The following factors were considered in the technology adoption and usage models:

AGE = The operator's age in years.

COLLEGE = A dummy variable taking the value of 1 if the dairy operator has a college degree, 0 if not.

COWS = The average number of milking-aged cows from 2004 and 2005.

DIVERSIFIED = A dummy variable taking the value 1 if the farm included any enterprise other than the dairy, 0 otherwise.

SUCCESSOR = A dummy variable taking the value 1 if the operator was planning to pass the dairy operation to a family successor upon retirement, 0 otherwise.

OFFFARMINCOME = The percentage of gross household income earned off the farm.

ACRESOWNED = The percentage of total farm acres operated owned by the operator.

TECHNOLOGY = A count variable representing the number of other technologies adopted to measure the farmer's propensity to adopt new technologies. Technologies included artificial insemination, total mixed ration feeding, DHIA, growth or production hormones, feeding silage, feeding balage, GPS technologies, computer adoption, and rotational grazing.

STATEMENTS = A count variable representing the number of financial statements that are generated for the operator's analysis, including: net income, balance sheet, cash flow, and owner's equity.

INTERNAL = A dummy variable taking the value of 1 if the farm's financial records are kept internally by the dairy operator, 0 otherwise.

Based upon Pearson correlation coefficients, no evidence of multicollinearity problems was detected. The data, however, were heteroskedastic. To correct for this problem, the Robust command in STATA was used.

Results

For the sample, the average farmer had 30 years of experience in the dairy industry, with average farm size 326 acres and 111 milking age cows. The average annual production per cow was 15,680 lbs., which is higher than the state average, suggesting that better managers were more likely to agree to the survey. Forty percent of the farmers had attended college. Thirteen percent planned to pass the dairy enterprise to their children upon retirement. Table 1 provides adoption statistics for each of the technologies, record-keeping systems, and statements of interest.

Table 2 shows results for whether the farmer had experience with using the Internet. Four factors were influential: farm size, whether a family successor was expected to take over the farm upon the farmer's retirement, the percentage of household income from off-farm sources, and the adoption of other technologies. For each additional cow in the herd, the probability of Internet experience increased by 0.0048 (so, for each additional 100 cows the probability increased by 0.48). Contrary to initial expectations, when a farmer had an expected family successor, he was less likely to have experience with using Internet technology. This is likely the result of farmers who have a subsequent generation involved in the operation depending on that generation for computer applications. The probability of having experience with the Internet increased with the proportion of additional household income that was obtained from an off-farm source. The probability of Internet experience increased by 0.16 for every additional technological innovation the farmer had adopted.

Analyzing whether the farmer had adopted a computerized record-keeping system, one independent variable was significant: each additional financial statement kept increased the probability of adoption of a computerized record-keeping system by 0.17.

Analyzing the number of financial measures tracked by the farmer, one factor was influential: the existence of a family successor. When the farm had an expected successor, approximately 1.3 additional financial measures were tracked. In explaining the number of financial statements generated for financial analysis and decision making, one factor was influential: whether the financial records were updated by the farm operator himself. If the records were updated by the operator, then 0.86 fewer statements were kept than if another party updated the financial records. This is likely due to time constraints associated with personal record-keeping.

Analyzing the factors influencing how often farm records were updated, having a college degree and/or a diversified operation reduced the frequency of updating (Table 3). Having a college degree increased the probability of updating records on a monthly basis by 0.13, and decreased the probability of updating on a daily basis by 0.10. Perhaps college graduates were less likely to believe they needed to update records on a frequent basis. The probability of a diversified operation updating records monthly was increased by 0.15 relative to a non-diversified operation. Likewise, the probability of a diversified operation updating records daily was decreased by 0.12 relative to a non-diversified operation. In cases where sufficient scale economies are realized in all enterprises on a farm, increased diversification is likely to further constrain time available for management tasks such as record-keeping.

A number of factors were significant in analyzing the factors influencing perceived usefulness of a computer. Age and previous technology adoption increased the computer's perceived usefulness, while diversification and having a family successor decreased the computer's perceived usefulness. For each additional year of age of the farmer, the probabilities of his responding "not at all useful" and "limited usefulness" were reduced while the probability of his responding "very useful" was increased. While previous studies have shown older farmers to be lower adopters of computers, results of this study do not suggest that this is due to perceived lower usefulness; perhaps the lower adoption rates are due to fewer available learning opportunities and/or shorter planning horizons with respect to the farm firm. For the diversified farmer, the probabilities of his responding "not at all useful" and "of limited usefulness" were increased by 0.22 and 0.18 respectively, while the probability of his responding "very useful" was decreased by 0.38. For the farmer expecting a family member to succeed him as the farm's operator, the probability of his responding "of limited usefulness was increased by 0.13, while the probability of his responding "very useful" was decreased by 0.32. This is consistent with earlier results reported in this paper showing that farmers expecting a family member to succeed them on the farm were less likely to have experience with using the Internet. Finally, for each additional technology adopted, the probability of the farmer responding "not at all useful" decreased by 0.08 while the probability of his responding "very useful" increased by 0.15. As expected, the technology adopters generally found computers to be of greater usefulness.

Analysis of factors affecting DHIA adoption and intensity of use are shown in Table 4. From the adoption model, herd size and prior technology adoption positively influenced the adoption of DHIA. Larger farmers had an increased probability of 0.0036 with each additional cow of using DHIA (thus, with 100 additional cows, the probability of adoption increased by 0.36). For each additional technology previously adopted, the probability of DHIA use increased by 0.30. Thus, as expected, the larger, more technologically advanced farmers were the users of DHIA. From adoption intensity analysis, off-farm income and previous technology adoption reduced the number of hours per week the operator spent reviewing DHIA output, while those having a family successor, who were diversified, or kept the farm records themselves spent more hours per week reviewing DHIA output.

Summary and Conclusions

A number of insights can be gleaned from the results of this study.

Of the computer adopters, older farmers tended to believe their computers were of greater usefulness for business purposes than did younger farmers. This does not imply that older farmers were the greater adopters, as this was not found and other studies have found older farmers to be lower computer adopters.

Farmers holding college degrees were more likely to update their financial records on a monthly basis.

Farmers of larger farms were more likely to have experience with the Internet and to be members of DHIA. These results are consistent with the results found in previous technology adoption studies that larger producers are the greater technology adopters.

Higher levels of off-farm income were associated with greater Internet experience, which is consistent with expectations because many farmers are exposed to the Internet and its benefits for a farm operation at their off-farm jobs. On the other hand, higher levels of off-farm income reduced the hours spent reviewing DHIA output. This is likely due to the tighter time constraints imposed by the off-farm job.

Diversified farmers were likely to update their financial records less frequently than non-diversified farmers. They were also more likely to view their computer as being less useful. Diversified farmers who were DHIA adopters spent more hours per week reviewing their DHIA output.

Technology adopters were more likely to have experience using the Internet, to perceive their computers are more useful, and to be DHIA adopters, though their time spent reviewing DHIA records was less extensive.

Having a family successor for the farm increased the time spent on management activities: it increased the time spent reviewing DHIA output and increased the number of financial measures tracked. On the other hand, farmers with family successors for the farm were less likely to have experience using Internet technologies and were more likely to view their computer as of limited usefulness to the farm operation.

Farmers who kept more financial statements were more likely to adopt computerized record-keeping systems. Those who kept their own records were less likely to generate as many statements, but those who were DHIA users spent more time analyzing DHIA data.

Overall, adopters of record-keeping technologies were larger producers and were also adopters of other technologies. While those with off-farm income were more likely to use the Internet, their intensity of use of record-keeping systems if adopted was lower. This may suggest that, while they are information adopters, they have less time to devote to analyzing the acquired information.

Generally, study results suggest that extension farm record-keeping programs intended to promote the use of record-keeping systems could target smaller, lower-technology farmers who have no family successor. The takeaway from this study for farm managers is the prevalence of state-of-the-art technology use among cohorts. Despite the relatively low expense of adoption of record-keeping systems relative to many other technologies, the adoption rates appear rather low. Assuming good record-keeping leads to more efficient and profitable operations, this would suggest there is significant room for improvement in both measures on a rather large portion of dairy farms.

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Table 1. Adoption statistics

Item	Percent
Uses Computer	78
Uses Computerized Financial Records	30
Uses the DHIA Record-Keeping System	36
Files Own Tax Returns without Aid of a Professional	4
Produces a Cash Flow Statement	60
Produces a Balance Sheet	42
Produces a Income Statement	38
Tracks Owner's Equity	20
Tracks Liquidity	68
Tracks Solvency	46
Tracks Profitability	42
Tracks Repayment Capacity	40
Tracks Financial Efficiency	28

Table 2. Marginal effects of logit and negative binomial regression analyses

Logit Analyses

	Experience with the Internet		Adoption of Computerized Record-Keeping Systems	
	Marginal Effect	Standard Error	Marginal Effect	Standard Error
Age	0.0127	0.0093	0.0105	0.0084
College	0.2705	0.2094	-0.0034	0.1815
Cows	0.0048**	0.0024	0.0012	0.0017
Diversified	-0.2581	0.2285	-0.1429	0.1861
Successor	-0.4401**	0.1883	-0.2349	0.1489
Offfarmincome	0.1116**	0.0048	0.0016	0.0031
Acresowned	-0.1748	0.3359	0.1127	0.2680
Technology	0.1570*	0.0943	0.0761	0.0713
Statements	n/a	n/a	0.1687***	0.0622
Internal	-0.0552	0.1904	0.0970	0.1622
% Correctly Predicted	64.44		77.78	
Pseudo R^2	0.2827		0.2225	
Observations	45		45	

Negative Binomial Regression Analyses

	No. of Financial Measures		No. of Statements Generated	
	Marginal Effect	Standard Error	Marginal Effect	Standard Error
Age	0.0148	0.0242	-0.0143	0.0187
College	0.2772	0.5603	0.0172	0.4657
Cows	0.0051	0.0053	0.0019	0.0040
Diversified	0.3911	0.5974	0.1229	0.4660
Successor	1.2557*	0.6701	0.4122	0.4967
Offfarmincome	0.0159	0.0097	0.0019	0.0082
Acresowned	0.0993	0.7862	0.2379	0.6402
Technology	-0.0049	0.2135	0.1791	0.1808
Internal	0.2707	0.4952	-0.8612**	0.3958
Pseudo R^2	0.0551		0.0599	
Observations	45		45	

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

Table 3. Ordered probit model results

Variable	Beta	Standard Error	Marg Effect	Standard Error	Marg Effect	Standard Error	Marg Effect	Standard Error	Marg Effect	Standard Error
	----------Frequency of Updating Records, Pseudo R^2=0.1140; 44 Observations----------									
	Overall Model		Yearly		Monthly		Weekly		Daily	
Age	-0.0124	0.0165	0.0021	0.0028	0.0029	0.0039	-0.0028	0.0039	-0.0021	0.0028
College	-0.6763*	0.4004	0.1334	0.0939	0.1256*	0.0735	-0.1611	0.1032	-0.0979*	0.0575
Cows	0.0027	0.0037	-0.0004	0.0006	-0.0006	0.0009	0.0006	0.0009	0.0004	0.0006
Diversified	-0.7574*	0.4388	0.1405	0.0956	0.1510*	0.0886	-0.1731	0.1080	-0.1185*	0.0709
Successor	0.4426	0.4057	-0.0643	0.0544	-0.1108	0.1114	0.0893	0.0755	0.0858	0.0910
Offfarmincome	-0.0056	0.0071	0.0009	0.0012	0.0013	0.0017	-0.0013	0.0017	-0.0009	0.0012
Acresowned	-0.6010	0.5507	0.1008	0.0955	0.1380	0.1349	-0.1378	0.1323	-0.1010	0.0969
Technology	0.1765	0.1538	-0.0296	0.0266	-0.0405	0.0380	0.0404	0.0374	0.0297	0.0269
Internal	0.2424	0.3389	-0.0404	0.0573	-0.0557	0.0797	0.0550	0.0779	0.0411	0.0588
----------Computer Usefulness, Pseudo R^2=0.1530, 35 Observations----------										
	Overall Model		Not at All Useful		Limited Usefulness		Moderately Useful		Very Useful	
Age	0.0495**	0.0214	-0.0094**	0.0048	-0.0101*	0.0060	0.0007	0.0021	0.0188**	0.0082
College	0.5392	0.4735	-0.0959	0.0854	-0.1106	0.1040	0.0013	0.0223	0.2051	0.1786
Cows	0.0043	0.0047	-0.0008	0.0009	-0.0009	0.0010	0.0001	0.0002	0.0016	0.0018
Diversified	-1.0710**	0.5075	0.2243*	0.1253	0.18118	0.0995	-0.0262	0.0439	-0.3791**	0.1607
Successor	-0.9783*	0.5631	0.2457	0.1771	0.1286*	0.0752	-0.0545	0.0611	-0.3197**	0.1519
Offfarmincome	0.0039	0.0077	-0.0007	0.0015	-0.0008	0.0016	0.0001	0.0002	0.0015	0.0029
Acresowned	0.9162	0.6458	-0.1730	0.1315	-0.1860	0.1505	0.0121	0.0399	0.3469	0.2453
Technology	0.4063**	0.1982	-0.0767*	0.0422	-0.0848	0.0532	0.0054	0.0175	0.1538**	0.0756
Internal	0.4677	0.4516	-0.0894	0.0917	-0.0925	0.0915	0.0066	0.0198	0.1753	0.1678
Statements	0.1917	0.1578	-0.0362	0.0318	-0.0389	0.0353	0.0025	0.0084	0.0726	0.0601

Table 4. Double hurdle model, adoption and intensity of DHIA use

Variable	Probit		Truncated Regression	
	Marginal Effect	Standard Error	Marginal Effect	Standard Error
Age	0.0057	0.0091	0.0058	0.0018
College	-0.0788	0.1999	-0.2315	0.3155
Cows	0.0036*	0.0021	0.0036	0.0025
Acresowned	-0.3068	0.3146	0.0358	0.3777
Offfarmincome	-0.0006	0.0035	-0.0202**	0.0091
Successor	-0.0166	0.2260	1.7036***	0.4774
Technology	0.3028***	0.1031	-0.4740***	0.1692
Diversified	0.2042	0.1955	1.0112*	0.5293
Internal	n/a	n/a	0.7228**	0.3679
Constant	n/a	n/a	1.1052	1.1201

Pseudo R-Squared: 0.5240; Percent correctly predicted: 88%