AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Adoption of Technology and Its Impact on Profitability of Young and Beginning Farmers: A Quantile Regression Approach

Arun Adhikari, Ashok K. Mishra and Sachin Chintawar[1]

Correspondence to:

Ashok K. Mishra
Associate Professor
Department of Agricultural Economics and Agribusiness
Louisiana State University
226 Ag. Admin. Bldg.
Baton Rouge, LA 70803
Tel: 225-578-0262
Fax: 225-578-2716
E-mail: amishra@lsu.edu

Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Atlanta, Georgia, January 31-February 3, 2009

Copyright 2009 by Adhikari, Mishra, and hintawar. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Adhikari and Chintawar are graduate students and Mishra is associate professor, Department of Agricultural Economics and Agribusiness, Louisiana State University, Baton Rouge, LA, 70803.
The views expressed here are not necessarily those of the Economic Research Service or the U.S. Department of Agriculture. This project was supported by the USDA Cooperative State Research Education & Extension Service, Hatch project # 0212495 and Louisiana State University Experiment Station project # LAB 93872.

Adoption of Technology and Its Impact on Profitability of Young and Beginning Farmers: A Quantile Regression Approach

Introduction

Technology adoption is observed as an increasing trend in every field. Agriculture cannot stay away from adoption of new technologies in farming. This embraces adoption of genetically modified crops, pests and insects resistant crops and organic farming as well. As a result of a cropping and production efficiency gains due to the adoption of new technologies, US farmers have steadily increased their farming for genetically modified crops. Adoption of technology in farming in the United States, has however, seen an increment in faster pace as compared with past innovations in plant varieties. The global area of genetically modified (GM hereafter) crops has increased from 2.8% in 1996 to 52.6% in 2001 (Buttel, 2002). In United States, the area of GM crops increased from 51% in 1996 to 68% in 2001.

Major GM crops grown in U.S. are BT (*Bacillus thuringiensis*) corn, HT (Herbicide tolerant) soybean and BT cotton. Bt corn is a genetically altered variety of maize to articulate the bacterial Bt toxin, which is susceptible to insect pests. HT soybean are meant to be highly resistant to broad spectrum herbicide, glyphosate, that helps farmers to lessen the weeds more efficiently using smaller amounts of less toxic and less importunate pesticides. Paz et al. points specific advantages of using HT soybean as it 1) decreases herbicide costs, 2) increase glyphosate applications compared to other types of herbicide, and 3) facilitate farm families to reassign their time to other income-earning activities. Bt cotton is a genetically modified variety of cotton by the insertion of one or more genes from a common soil bacterium, *Bacillus thuringiensis*. These three crops occupy around 95% of total GM crops grown in U.S (Buttel, 2002). Among these, HT soybean occupies the largest area followed by BT corn and BT cotton. Adoptions of these GM crops, i.e., BT corn, HT soybean and BT cotton have increased steadily since their introduction. Of the 41.5 Mio hectares of GM crops sown on commercial basis in 1999, 53% were soybeans, 27% corn and 9% cotton respectively.

Young and Beginning farmers (YBFR, defined as farm operator's less than 35 years old with farming experience of less than 10 years) have different needs than the established farmers. YBFR lack capital and experience in farming, lack the scale of operation needed to make profits, and they often face high land values and production costs (Mishra, Wilson and Williams, 2006). In addition, YBFR and their spouses are more educated and more likely to spend to find higher paying jobs outside the farming business (Mishra et al., 2002). As a result, they are reluctant to try traditional and time consuming farming processes using older technologies. YBFR are innovative and keen to adopt new technologies save time spent on farming. A YBFR must therefore acquire good information about farming techniques, managing a farm business, adhering to regulations, minimizing production costs, and making the business profitable after adopting new technologies, such as GM crops.

The prime objective of this paper is to identify factors that impact the adoption of GM crops by YBFR. A secondary objective of this study is to assess the impacts of GM crop adoption[2] on farm profitability of young and beginning farmers. More specifically, the purpose of the study is to determine whether or not the adoption of GM crops increased the profitability of YBFR. In addition, this study will also explore the impact of other factors (such as farm, operator, demographic, and financial characteristics) farm profitability of YBFR. Due to heterogeneity in profitability we investigate the impact of adoption of GM crops over the entire farm profitability distribution. Profitability computation of YBFR would be significant in making strategic business plans and policies for future production and to assess the firm's goals to craft future decisions.

---

[2] Measured as the share of GM crop acres in total planted ares. We use share of corn, cotton, and soybean acres in total planted acres.

Data Source for Young and Beginning Operators

Data for this analysis are from the 2004-2006 Agricultural Resource Management Survey (ARMS). ARMS is conducted annually by the Economic Research Service and the National Agricultural Statistics Service. The survey collects data to measure the financial condition (farm income, expenses, assets, and debts) and operating characteristics of farm businesses, the cost of producing agricultural commodities, and the well-being of farm operator households.

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

The 2004 to 2006 ARMS collected information on farm households in addition to farm business data. For example, it collected detailed information on off-farm hours worked by spouses and farm operators, the amount of income received from off-farm work, net cash income from operating another farm/ranch, net cash income from operating another business, and net income from share renting. The heavy emphasis in off-farm employment of operators and spouses suggests that the farm household has an alternate goal to generating maximum household income for the farm business operation. Furthermore, income received from other sources, such as disability, social security, and unemployment payments, and gross income from interest and dividends was also counted. The 2004 to 2006 ARMS contains a sample of 19,638 farms, whose primary operators had less than 10 years of farming experience, which could be classified as farms operated by young and beginning farmers and ranchers (YBFR). The survey design of ARMS allows each sampled farm to represent a number of farms that are similar, referred to as a survey expansion factor. The expansion factor, in turn, is defined as the inverse of the probability of the surveyed farm being selected. Weighted means (expanded by the expansion factor, which is the weight) procedure is used to extrapolate representative sample to a population. This is based on the procedure that is specific to the ARMS data (see Dubman for details).

Literature Review

Although there has been a plethora of literature in farm management literature that focuses in various factors that impact profitability of various types of farms and in various regions of the U.S. (see Fox, Bergen, and Dickson, 1993 and Rougoor et al., 1998), none have directly addressed the issue of technology adoption by young and beginning farm households and its impact on farm profitability. Published research on the financial impacts of using Genetically Modified (GM) crops has been mixed. The data has been limited and at the same time very localized. For example, Roberts, Pendergrass, and Hayes used field trials in West Tennessee to conduct an economic analysis of Roundup Ready soybeans. The authors concluded that returns from Roundup system were 13 percent higher than the returns for the second most profitable system. Higher returns were associated with higher yields and lower costs. Research from experimental trails in Mississippi (Arnold, Shaw, and Medlin) and North Carolina (Marra, Carlson, and Hubbell) showed higher yields and net returns from Roundup Ready soybeans versus conventional varieties. However, a comparison of costs and returns with regard to Roundup Ready and conventional corn varieties in Kentucky did not show a significant difference in returns above seed, herbicide, and fixed costs (Ferrell, Witt, and Slack).

Economic analysis using experimental data show a benefits related to herbicide tolerant crops over conventional varieties, results based on producer survey have not been clear. Using the

1997 national survey of soybean producers, McBride and Brooks compared costs across herbicide-tolerant soybean over conventional varieties and found no significant difference in costs. Fernandez-Cornejo, Klotz-Ingram, and Jan, using the same data but controlling for cropping practices, agronomic conditions, and producers attributes found no statistical significance in the rate of returns between farmers who adopted herbicide-tolerant soybean over conventional varieties. While studying the impacts of adopting herbicide-tolerant corn on net returns, Fernandez-Cornejo and Klotz-Ingram did not find any significant results. While these studies focused on the costs and benefits of adopting genetically engineered crops (soybean and corn) but are limited in many ways. First, none of these studies have investigated the issue of adoption and its impact on farm profitability. Second, there is a possibility that that decision to adopt is jointly determined with measure of profitability. Third, previous studies in farm profitability have only investigated cash grain and dairy farms and none have focused on young and beginning farmers (YBFR). It is likely that young and beginning farmer has a different set of attributes and skills. For example, YBFR are more likely to have higher education, likely to work off the farm, and likely to adopt new technology such as GM crops. The notion being that adoption of GM crops would reduce farming time and potentially increase off-farm work hours.

Returns to assets is widely used measure of financial performance (Barry, et al.) that can be influenced many aspect of the farm business other than the adoption of GM crops. With regard to factors affecting financial performance in general, Fox, Bergen, and Dickson, 1993 and Rougoor et al., 1998 provide reviews of a large number of studies in the area of financial performance in farm management. Their reviews concluded that personal attributes and goals were important in explaining profitability differences across farms. The inclusion of farm operator characteristics such as education may give some insights into the influence of training, experience, and demographics on farm business financial performance. These factors affect the production function (Huffman, 1977; Becker). Huffman (1977) and Lins et al. show that higher levels of farm operator education are likely to induce adoption of new technology. Education is hypothesized to have a positive effect on financial performance, as predicted by human capital theory. Better educated farmers tend to be more successful and to receive the same or better returns from farming as elsewhere.

More recently Gloy and LaDue, 2003 and Gloy, Hyde, and LaDue, 2002 used age of the operator as a variable in explaining financial performance of diary farms in New York. In both studies this variable proved to be insignificant. In this study, we use age of the operator (*AGE*), possibly reflecting farming experience and educational level of the farm operator, with those having some education (*EDUC*), as factors affecting profitability of YBFR. Several farm production characteristics are hypothesized to contribute to a farm's profitability: nonfarm income, machinery value per dollar of output, participation in government commodity programs, ratio of cash operating expenses, and diversification. Nonfarm income may affect labor and management. If the source of the nonfarm income is wages and salaries (in this study we use income from all nonfarm sources), then one would expect the effort expended to detract from farm labor and management therefore contributing to lower performance of the farm.

Farm size is another factor related to profitability (Boessen *et al*.; Ford and Shonkwiler; Haden and Johnson; Kauffman and Tauer; Sonka *et al*.). While Matulich found economies of scale in dairying, Kauffman and Tauer's findings indicated no strong relationship between number of cows and the probability of higher returns. Haden and Johnson found a positive relationship between farm size and financial performance. Hoffman indicated that well managed farms, based on farm records, are better able to compete in per-unit profitability with farms many times larger. In our study, we use two different variables to measure the impact of managerial ability on profitability of YBFR. Business plans are essential part of any business. It is road map about the business and its future plans. The first variable, business plan (*BPLAN*) is used as a dummy variable to study the impact of business plan on profitability of the farms owned/operated by YBFR and is hypothesized to have a positive impact on ROA. The second variable, *COMP*, keeping computerized books and records is also used as a proxy for managerial ability. The notion being that farmers who keep computerized records of income and expenditures (bookkeeping) are more likely to keep track of their income and expenses (Mishra, El-Osta, and Johnson) and are able make sound farming decisions.

Conceptual Framework and Empirical Procedure

Consider a profit maximizing farm operator who in each period selects the combination of inputs and outputs that maximizes profits[3] (total revenue minus total cost) subject to a production constraint or endowments. Specifically,

$$\begin{aligned}
&\text{Max } \Pi = \left[\sum \mathrm{P_i} Q_i\left(k, \mathrm{P_i}, \mathrm{I}, \theta\right)\right] - \left[\sum \mathrm{C_j}\left(Q_{j,} \, x_j, L, \omega_j, \theta\right)\right] \\
&s.t. \qquad g_j\left(x_j\right) \leq X_j \qquad j = 1,2 \ldots n. \\
&\mathrm{I_t} = f\left(A, H\right) \\
&L = L_o + L_h
\end{aligned} \tag{1}$$

where Π is net profits (net farm income), $\mathrm{P_i}$ denotes a vector of output prices, and Q_i denotes a vector of output produced. Production depends on the farm operator's level of human capital (education and experience), price of output, various farm characteristics, and managerial ability θ. On the cost side, $\mathrm{C_j}$ represents the cost of production, which depends on the quantity produced (Q_j), a vector of inputs x_j from which the farm operator can choose to produce Q_i, a vector of input prices w_j, and a vector of farm characteristics, and managerial ability, θ; L is total effective labor requirement; L_o is total family labor (paid and unpaid); L_h is total hired labor input. The function $g_j(.)$ ensures that the total demand for the n inputs (x_j) cannot be greater than the initial endowment of inputs X_j; and I_t denotes operator's knowledge about GM crop technology

---

[3] In this model we ignore risk preference and uncertainty and also assume that technology is fixed.

(measured as acres in GM crops); *A* represents operator's access to information regarding GM crop technology (such as farm management consultants, Internet, county agents, etc); *H* is operator's human capital endowments defined by age, education, and experience. Profits for the farm can be measures by net farm income. Since our data is cross-sectional prices are assumed that all farmers face the same output price and are fixed for that period. The general model provides the basis for estimating farm profitability with adoption of GM technology. Based on this information one can estimate the following reduced form model

$$\begin{aligned} NFI &= \alpha_0 + \sum \alpha_{ij}\Delta_{ij} + \beta G + \varepsilon_1 \\ G &= Z\phi + \varepsilon_2 \end{aligned} \tag{2}$$

where *NFI* is net farm income and Δ_{ij} is a vector of farm, operator, and financial characteristics affecting profitability of farms operated by YBFR as described by θ in equation 1; *G*, binary vector denoting the adoption of Gm crops (i.e., *G*=1 if technology adoption occurs, 0 otherwise); *Z*, a matrix of variables affecting the adoption of GM crops; and ε_1 and ε_2 are vectors of errors. Resource-based (that is assets in agriculture) is a better measure of financial performance (Bharadwaj), we replace the dependent variable (NFI) in equation 2 with Returns on assets (ROA), which is another measure of profitability that is widely used in the farm management literature. ROA ids the ratio of net farm income to total assets and is the measure used in this study. ROA is defined as:

$$ROA = \left(\frac{Net\ Farm\ Income}{Total\ Farm\ Assets}\right) \tag{3}$$

where *Net farm income* (NFI) is the accrual net farm income and *Total Farm Assets* is the market value of farm assets in 2005. This measure has been used by Gloy and LaDue, 2003; and Gloy, Hyde, and LaDue, 2002 to measure financial performance of farmers in New York. ROA is hypothesized to be a function of operator and farm characteristics and management strategies used to manage the farm. Specifically, we estimate the following equation using a weighted least squares procedure.

$$ROA = \alpha_0 + \sum \alpha_{ij}\Delta_{ij} + \beta G + \varepsilon_1 \qquad 4.1$$

$$G = Z\varphi + \varepsilon_2 \qquad 4.2$$

where, (i =1.......n),

ROA is net farm income per dollar of assets,

Δ_{ij} are a set of operators, farm, and financial characteristics,

α_{ij} is a vector of parameters to be estimated, and,

ϕ is a vector of parameters to be estimated in GM adoption model.

The independent variables hypothesized to affect the farm's profitability encompass the three following areas: farm operator characteristics; farm characteristics such as production and marketing efficiency measures; and management strategies.

There is a possibility that the decision to adopt GM crop is endogenous to farm financial performance. Specifically, as shown in equation 1, adoption of a GM crop impacts productivity and/or cost of production, this in turn impacts net returns. A YBFR will choose to adopt a GM crop (in our case plant GM crops) if the expected profits of doing so exceeds the some threshold profits, which could be interpreted as the expected returns of non-adoption plus a premium for switching to a new technology (Burrows). Following Maddala and Amemiya, equation 4.2 could be considered as reduced form equation through the exclusion of ROA from *Z*.

In assessing the impact of GM crop adoption on financial performance on YBFR we are employing the quantile regression approach. For a single equation econometric model, the parameter coefficients are generally estimated as:

$$\hat{\beta} = \min_{\beta \in R^P} \sum_{i=1}^{n} \left(y_i - x_i^{/} \beta \right)^2 \qquad (5)$$

where y_i is the endogenous variable and x_i is a vector of exogenous variables and with p representing the number of parameters to be estimated.

The single equation econometric model can be extended to quantile regression (see Koenker and Bassett, 1978 and 1982 for details about quantile regression) to examine the changes in coefficients across the distribution of the endogenous model. The quantile regression provides parameter coefficients estimation are any quantile in the range from between 0 to 1 conditional on the covariates or exogenous variables. This can be represented as:

$$\hat{\beta}(\tau) = \min_{\beta \in R^P} \sum_{i=1}^{n} \tau \left(y_i - x_i^{/} \beta \right)^2 \quad for\ any\ quantile, \tau \in (0,1)$$
$$or \tag{6}$$
$$\hat{\beta}(\tau) = \min_{\beta \in R^P} \left[\sum_{i \in \{i : y_i \geq x_i^{/} \beta\}} \tau \left| y_i - x_i^{/} \beta \right| + \sum_{i \in \{i : y_i \leq x_i^{/} \beta\}} (1-\tau) \left| y_i - x_i^{/} \beta \right| \right]$$

We use the quantile regression defined in equation (6) as the basis for our empirical model presented here following a reduced-form methodology that uses generals predictions from the economic model outlined above to guide the empirical work. Our quantile model specification follows equation 5 and can be specified as:

$$Q_\theta \left[y \mid X \right] = \alpha_\theta + \mathbf{X}\beta_\theta \tag{7}$$

where y is land value, $Q_\theta \left[y \mid \mathbf{X} \right]$ is the θ^{th} quantile of y conditional on covariate matrix, $\mathbf{X}$, that includes farm, operator, and predicted values of share of acreage in GM con, GM cotton, and GM soybean, along with other financial, off-farm work, and farm size variables and the coefficients β_θ represent the returns to covariates at the θ^{th} quantile.

Results

Tobit parameter estimates for the adoption-model[4] (equation 4.2) for share of GM crops are presented in Table 1. Higher log likelihood value and Pseudo-R^2 of the model for the population of YBFR indicates that the overall fit was good. Results show that young farm operators (*AGE*) are significantly likely to adopt GM crops (corn, soybean, and cotton) and statistically significant variables in the adoption model are similar in all three cases. Result show that in all cases of adoption off-farm work experience decreased the share of acreages in GM crops. This finding in counter to the belief that young and beginning farmers may adopt GM crops to decrease farming time, thereby more time to work off the farm. On the other hand, results of our study show that educated YBFR operators are more likely to adopt GM cotton and soybean crops. Results indicate that an additional year of schooling increases the acreage of GM cotton and soybean cotton by approximately 0.02 percent.

Results in table 1 show that large farm operators (farm with sales of more than $500,000) are more likely to adopt GM crops than their counterparts. Cropping efficiency, ratio of gross cash farm income to total variable costs (a proxy for farming experience, Goodwin and Mishra, 2004), has a negative and significant impact on GM crop adoption by YBFR. More experience on the farm may contribute to more efficiency, at least to the extent that farmers lean by doing. This result suggests that experienced farmers have smaller acreage in GM crops. Another interesting finding is that risk averse YBR operators[5] are more likely to adopt GM crops. This is consistent with the notion that GM crops may reduce production risks. Results in table 1 indicate that, compared to full owners, part-owners (*POWNER*) and tenants (*TENANT*) are more likely to adopt GM crops.

Farms specializing in cash grains are more likely to adopt GM crops such as corn and

---

[4] Using the Heckman's technique we tested the model for self-selection and found that the parameter was not significant.

[5] Ratio of crop insurance premiums paid to total variable cost is used as a proxy for risk aversion. The notion being that higher the share of crop insurance premiums in total viable expenses, higher the risk aversion.

soybean than other farm types. Regional location of the farms also plays an important role in adoption of GM crops by YBFR. Results indicate that, relative to those in the Mississippi Portal region, adoption of GM corn was more likely among YBFR producers in the Heartland, Northern Crescent, Northern Great Plains, Prairie Gateway, Eastern Upland, and Southern Seaboard. However, adoption of GM soybean is more likely among YBFR producers in the Heartland region Finally, with no surprise adoption GM cotton was more likely among YBFR in the Prairie Gateway and Sothern Seaboard regions, to those in the Mississippi Portal region.

Impact on Farm Profitability

The parameter estimates for the adoption-impact model (equation 4.1) for YBFR producers on financial performance is presented in Table 2. The pseudo-R^2 in Table 2 increases with quantile. The fit for the 20th was not good. The impact of GM crop adoption was significantly different from zero for only two quantile (50 and 90). For example, adoption of GM corn decreased farm profitability (ROA) by 1.3 percent in the 50th quantile and about 0.7 percent in the 90th quantile. On the other hand, adoption of GM cotton by YBFR increased farm profitability (ROA) by a small percentage (0.1 and 0.2 percent for 50th and 90 percentile). Our results are consistent with the finding of McBride and El-Osta, who found that adoption of Bt corn and Ht corn decreased crop operating margins. The coefficient of operators' education is *EDUC* is negative and statistically significant at the 1 percent level of significance for both 50th and 90th percentile. However, the magnitude of the impact is higher at the higher quantile. Specifically, results indicate that an additional year of schooling decreased ROA by 0.04 percent in the 50th quantile about 0.1 percent for YBFR in 90th quantile. This finding is not surprising since many YBFR tend to have higher education, operate smaller farms, and are likely to work more off the farm (Mishra et al., 2002). This result may imply that better educated YBFR are likely to get higher returns to human capital from off-farm work, are likely to work off the farm, and in the process have a negative impact on the farm's financial performance (ROA). A farm operator may generate a higher total net income by combining on and off-farm work, but when investigating the financial performance of farm firms operated by YBFR, what matters the most is farm income.

The coefficient of number of decision makers on the farm (*NUM_DECIS*) is positive and statistically significant at 1 percent level of significance for both 50th and 90th quantile. Results indicate that an increase in the number of person making farm management decisions increases farm financial performance in both quantile. Findings in table 2 suggest that increasing the number of decision makers increase financial performance by about 0.3 percent for YBFR operators in the 50th quantile and by about 0.4 percent for YBFR in the 90th quantile. This finding is consistent with Johnson and Morehart's argument that as farms increase in size and complexity, various people in the management process have expertise in various aspect of farm management that can help in the financial progress of the firm and may increase financial performance. Results in table 2 indicate that large farms have higher profitability in both 50th and 90th quantile, however, the magnitude of the impact varies with quantile. These results are consistent with the findings of Ford and Shonkwiler; Haden and Johnson; El-Osta and Johnson, and Mishra, El-Osta, and Johnson. These results suggest overall economies of scale. Finally, results in table 2 indicate that YBFR operators with higher debt to asset ratio have higher profitability. A possible explanation for this could be that large farms have higher debt and large farms are more likely to adopt new technologies such as GM crops.

Summary and Conclusions

With renewed focus on young and beginning farmers and ranchers in the policy arena, this study identifies factors that contribute to the profitability of young and beginning farmers and ranchers (YBFR) in the U.S. A weighted regression analysis was used on data from the 2004-2006 Agricultural Resource Management Survey (ARMS) to measure the profitability of young and beginning farmers given farm and operator characteristics, production and marketing, and risk management strategies. Particular attention was given to the impact of adoption of GM crops on farm profitability. This study correct for the simultaneity of technology adoption and farm profitability. Further, we employ quartile regression approach to investigate the impact of GM crop adoption on the distribution of farm profitability.

Results indicate that adoption of GM crops is negatively correlated to operator's off-farm work experience and age of the operator. On the other hand, adoption of GM crops is positively correlated with risk aversion. That is more risk averse farmers are likely to adopt GM crops. YBFR who are tenants and part owners have a higher share of GM crops compared to full land owners. More experienced farmers are less likely to adopt GM crops. Results also show that educated YBFR have lower share of GM cotton and soybean cotton. Large farms and farms specializing in cash grains are more likely to adopt GM corn and soybean. Location of the farm plays an important role in adoption of GM crops.

Our result shows that the adoption of GM corn decreased farm profitability (ROA) in higher quantiles. On the other hand, adoption of GM cotton by YBFR increased farm profitability. Educational attainment of the YBFR operator has a impact on farm profitability at higher quantiles. Findings here show that an increase in the number of person making farm management decisions increases farm profitability at higher quantiles. Finally, findings of our study indicate that large farms and farm with higher debt to asset ratio have higher farm profitability.

References

Amemiya, T. “Qualitative Response Models: A Survey.” *Journal of Economic Literature* 19 (Dec. 1981): 1483-1536.

Arnold, J., D. Shaw, and C. Medlin. “Roundup Ready Programs Versus Conventional Programs: Efficacy, Varietal Performance, and Economics.” *Proceedings of the Southern Weed Science Society* 1998. pp. 272-73.

Barry, P., P. Ellinger, J. Hopkin, and C. Baker. *Financial Management in Agriculture*, Interstate Publishers, Inc, Danville, IL. 1995.

Barlett, P. F. “Microdynamics of Debt, Drought, and Default in South Georgia.” *American Journal of Agricultural Economics* 66 (1984):836-843.

Becker, G. S. *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*. New York: National Bureau of Economic Research and Columbia University Press. 1975.

Bharadwaj, A. “A Resource-Based Perspective on Information Technology Capability and Firm Performance: An Empirical Investigation” *MIS Quarterly*, Vol. 24, No. 1 (Mar., 2000), pp. 169-196

Boessen, C. R., A. M. Featherstone, L. N. Langemeier, and R. O. Burton, Jr. “Financial Performance of Successful and Unsuccessful Farms.” *Journal of American Society of Farm Managers and Rural Appraisers,* 54 (April 1990):6-15.

Burrows, T. “Pesticide Demand and Integrated Pest Management: A Limited Dependent Variable Analysis.” *American Journal of Agricultural Economics* 65 (Nov. 1983):806-10.

Calvin, L. *Participation in the U.S. Federal Crop Insurance Program*. U.S. Department of Agriculture, Economic Research Service , Washington DC, Tech. Bulletin # 1800, 1992.

Chavas, J. P. and M. Aliber. “An Analysis of Economic Efficiency in Agriculture: A Nonparametric Approach.” *Journal of Agricultural and Resource Economics* 18(1993):1-16.

Cunningham-Dunlop, C. *A Five-Year Analysis of New York Egg Farm Management Factors.* A.E. Res. 82-18 Ithaca: Department of Poultry and Avian Sciences, Cornell University, June 1982.

Dubman, R.W. “Variance Estimation with USDA’s Farm Costs and Returns Surveys and Agricultural Resource Management Study Survey” *AGES 00-01*(2000) Economic Research Service, U.S. Department on Agriculture, Washington D.C.

El-Osta, H. S. and J. D. Johnson. *Determinants of Financial Performance of Commercial Dairy Farms.* Technical Bulletin # 1859, Economic Research Service, U.S. Department of Agriculture, Washington D.C., 1998.

Ellinger, P.N., P.J. Barry, T.L. Frey, and J.T. Scott, Jr. *Financial Characteristics of Illinois Farms 1985-1986.* University of Illinois at Urbana-Champaign, Department of Agricultural Economics, 1987.

Fernandez-Cornejo, J., C. Hendricks, and A. Mishra. “Technology Adoption and Off-Farm Household Income: The Case of Herbicide-Tolerant Soybeans.” *Journal of Agricultural and Applied Economics*, Vol. 37(3), 2005:549-563.

Fernandez-Cornejo, J., C. Klotz-Ingram, and S. Jan. “Farm-Level Effects of Adopting Genetically Engineered Crops in the U.S.A.” NE-165 *Conference Proceedings, Transitions in Agbiotech: Economics of Strategy and Policy,* edited by William Lesser, 2000, pp. 55-74.

Fernandez-Cornejo, J. and C. Klotz-Ingram. “Economics, Environmental, and Policy Impacts of Genetically Engineered Crops for Pest Management.” Paper presented at the Northeast Agricultural and Resource Economics Association meetings, Ithaca, NY, June 1998.

Ferrell, J., W. Witt, and C. Stack. "Integrating Glyphoste into Corn Weed Management Strategies." *Proceedings of the Southern Weed Science Society* 1999. pp. 27-28.

Ford, S.A. and J.S. Shonkwiler. "The Effect of Managerial Ability on Farm Financial Success." *Agricultural and Resource Economics Review* 23 (2)(1994):150-157.

Fox, G., P. A. Bergen, and E. Dickson. (1993). "Why Are Some Farms More Successful than Others? A Review." In A. Hallam (ed.), *Size, Structure, and the Changing Face of American Agriculture* (pp. 232-250). Boulder, CO: Westview Press.

Hackbart, M. M., and D. A. Anderson. "On Measuring Economic Diversification': Reply". *Land Economics* 54 (1978):111-112.

Garcia, P., S.T. Sonka., and M.S. Yoo. "Farm Size, Tenure, and Economic Efficiency in a sample of Illinois Grain Farms." *American Journal of Agricultural Economics* 64 (1982):119-23.

Gloy, B. A., J. Hyde, and E. L. LaDue. "Dairy Farm Management and Long-Term Farm Financial Performance." *Agr. and Resour. Econ. Rev.* 31,2(2002): 233-47.

Gloy, B. A. and E. L. LaDue. "Financial Management Practices and Farm Profitability." *Agricultural Finance Review*, 63:2(Fall 2003):157-174.

Goodwin, B. K. and T. C. Schroeder. "Human Capital, Producer Education Programs, and the Adoption of Forward Pricing Methods." *American Journal of Agricultural Economics*, 76, 936, (1994).

Haden, K.L. and L.A. Johnson. "Factors Which Contribute to Financial Performance of Selected Tennessee Dairies." *Southern Journal of Agricultural Economics*, 21 (1989):105-112.

Henderson, Dennis R. 1984. "Electronic Marketing in Principle and Practice." *American Journal of Agricultural Economics*. December:848-853.

Hensher, D. A., and L.W. Johnson. 1981. Applied Discrete Choice Modeling. New York: John Wiley.

Hoffman, Robbin. "Size and Profitability: It's Better to Be Good than Big, But You Can't Beat Good and Big." *Farm Journal (Mid-March)*, 1996: 2-3.

Holt, Donald. 1985. "Computers in Production Agriculture." *Science*. 228. April:422-27.

Huber, P. J. The behavior of maximum likelihood estimates under nonstandard conditions. In *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability*. Berkeley, CA: University of California Press, 1(1967):221–23.

Huffman, W. E. "Allocative Efficiency: The Role of Human Capital." *Quarterly Journal of Economics*. 91(1977):59-79.

Johnson, J. and M. Morehart. "*Farm Business Management*" Chapter 4.2, Agricultural Resources and Environmental Indicators, 2996/EIB 16. http://www.ers.usda.gov/publications/arei/eib16/eib16_4-1.pdf/ (Accessed on Jan. 31, 2008).

Judge, G. G., W. E. Griffiths, H. Lutkepohl, and T. Lee. *The Theory and Practice of Econometrics*. Second Edition. New York, NY: John Wiley and Sons, 1985.

Kauffman, J., B., and L.W.Tauer. "Successful Dairy Farm management Strategies Identified by Stochastic Dominance Analysis of Farm Records." *Northeastern Journal of Agricultural and Resource Economics*. 15(1986):168-77.

Koenker, R., Bassett, G. 1978. "Regression quantiles." *Econometrica* 46 (1), 33–50.

Koenker, R., Bassett, G. 1982. "Robust tests for heteroscedasticity based on regression

Korth, B. D. Factors for Determining Financial Success for Farm Managers. Unpublished M.Sc. Thesis: University of Nebraska, Lincoln, Nov. 1984.

Kramer, R. and R. Pope. "Participation in Farm Commodity Programs: A Stochastic Dominance Analysis." *American Journal of Agricultural Economics* 63(1981):119-128.

Lins, D., P. Ellinger, and D. Lattz. "Measurement of Financial Stress in Agriculture." *American Finance Review*, 47(1987):43-52.
Luckham, W. R. "Financial Ratios for Grade A Dairy Farms in Virginia." *Farm Credit Administration Research Journal* 1(1976): 18-24.
Maddala, G. *Limited-Dependent and Qualitative Variables in Econometrics.* Cambridge University Press, 1983.
Marra, M., G. Carlson, and B. Hubbell. Economic Impacts of the First Crop Biotechnologies. Internet site http://www.ag-econ.ncsu.edu/faculty/marra/online.html/ (Accessed April 2006).
Matulich, S. C. "Efficiencies in Large-Scale Dairying: Incentives for Future Structural Change." *American Journal of Agricultural Economics* 60 (1978):642-647.
McBride, W. and H. El-Osta. "Impacts of the Adoption of Genetically Engineered Crops on Farm Financial Performance." *Journal of Agricultural and Applied Economics, Vol. 34. No. 1, 2002.*
McBride, W. and Nora Brooks. "Survey Evidence on Producer Use and Costs of Genetically Modified Seed." *Agribusiness* 16(2000):6-20.
Melichar, Emanuel. "Capital Gains versus Current Income in the Farming Sector." *American Journal of Agricultural Economics* 61 (1979):1085-1102.
Mishra, Ashok K. and Hisham S. El-Osta. "Factors Affecting Succession Decisions in Family Farm Businesses: Evidence from a National Survey" Forthcoming in 2007 *Journal of the American Society of Farm Managers and Rural Appraisers.*
Mishra, A. K., H. El-Osta, and J. Johnson. "Factors Contributing to Earnings Success of Cash Grain Farms." *Journal of Agricultural and Applied Economics, Vol. 31. No. 3, 1999.*
Roberts, R., R. Pendergrass, and R. Hayes. "Economic Analysis of Alternative Herbicide Regimes on Roundup Ready Soybean." *Journal of Production Agriculture* 81(1986): 219-226.
Rougoor, C. W., G. Trip, R. B. M. Huirne, and J. A. Renkema. (1998). "How to Define and Study Farmers' Management Capacity: Theory and Use in Agricultural Economics." *Agricultural Economics* 18, 261S272.
Sonka, S. T., R. H. Hornbaker, and M. A. Hudson. "Managerial Performance and Income Variability for a Sample of Illinois Cash Grain Producers." *North Central Journal of Agricultural Economics,* 11(1989):39-47.
U. S. Department of Agriculture. *Census of Agriculture, 1997*, Washington D.C. 1997, 2002.
White, H. "A heteroscedasticity-consistent covariance matrix estimator and a direct test for heteroscedasticity." *Econometrica.* 48(May 1980):817–30.

Table 1: Tobit Estimates of Adoption-Decision Model in Genetically Modified (GM) corn, cotton and soybeans, 2004 to 2006

Variables	Parameter Estimates					
	Corn		Cotton		Soybean	
	Par Est.	dy/dx	Par Est.	dy/dx	Par Est.	dy/dx
Intercept	-0.558*** (0.00)	-	-2.256*** (0.32)	-	-0.474*** (0.11)	
Operator's off farm work experience *(OPOWKEXP)*	-0.003*** (0.00)	-0.001*** (0.00)	-0.011*** (0.00)	-0.001*** (0.00)	-0.002*** (0.00)	-0.0003*** (0.00)
Operator's age *(EDUC)*	-0.002 (0.00)	0.001 (0.00)	0.027*** (0.01)	0.002*** (0.00)	0.015*** (0.00)	0.002*** (0.00)
Operator's education *(AGE)*	-0.004* (0.00)	-0.001* (0.00)	-0.007 (0.01)	-0.001 (0.00)	-0.002*** (0.00)	-0.002*** (0.00)
Operator's age squared *(AGESQ)*	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
Dummy for farm sales of more than $500,000 *(LARGE)*	0.191*** (0.01)	0.033*** (0.00)	0.701** (0.04)	0.053** (0.04)	0.129*** (0.01)	0.020*** (0.00)
Cropping efficiency (ratio of gross cash farm income to total variable costs) *(CROP_EFF)*	-0.007*** (0.00)	-0.001*** (0.00)	-0.019*** (0.01)	-0.001*** (0.00)	-0.001 (0.00)	0.000 (0.00)
Risk aversion (ratio of crop insurance premiums to total variable cost) *(R_AVERSION)*	0.567*** (0.17)	0.094*** (0.03)	2.089*** (0.76)	0.154* (0.06)	0.464*** (0.15)	0.069*** (0.02)
Tenant *(TENANT)*	0.161** (0.01)	0.030*** (0.00)	1.073*** (0.06)	0.092*** (0.01)	0.268*** (0.02)	0.047*** (0.00)
Part-Owner *(POWNER)*	0.204** (0.10)	0.035*** (0.00)	0.796*** (0.06)	0.060*** (0.00)	0.253*** (0.01)	0.038*** (0.00)
Mean productivity index *(MEANPI)*	0.000 (0.00)	0.000 (0.00)	-0.004 (0.00)	0.000 (0.00)	0.001 (0.00)	0.000 (0.00)
Farm is cash grain *(CGRAIN)*	0.261*** (0.02)	0.051*** (0.00)	-0.194*** (0.04)	-0.014*** (0.00)	0.592*** (0.01)	0.122*** (0.00)
Farm located in Heartland region *(HEART)*	0.351*** (0.02)	0.74*** (0.00)	-0.699*** (0.08)	-0.047*** (0.00)	0.112*** (0.02)	0.018*** (0.00)
Farm located in Northern Crescent region *(NORTHC)*	0.325*** (0.02)	0.066*** (0.00)	-	-	-0.047*** (0.01)	-0.007*** (0.00)
Farm located in Northern Great Plains *(NORTHGP)*	0.081*** (0.02)	0.014*** (0.00)	-	-	-0.301*** (0.03)	-0.037*** (0.00)
Farm located in Prairie Gateway region *(PGATE)*	0.119*** (0.02)	0.022*** (0.00)	0.203*** (0.04)	0.015*** (0.00)	-0.292*** (0.02)	-0.037*** (0.00)

Farm located in Eastern Uplands region *(EUPLAND)*	0.098*** (0.02)	0.017*** (0.00)	-0.358*** (0.07)	-0.025*** (0.00)	-0.213*** (0.02)	-0.028*** (0.00)
Farm located in Southern Seaboard *(SSBOARD)*	0.080*** (0.02)	0.014*** (0.00)	0.343*** (0.04)	0.027*** (0.00)	-0.040** (0.02)	-0.006*** (0.00)
Farm located in Fruitful rim *(FRIM)*	-0.039*** (0.02)	-0.006*** (0.00)	-0.234*** (0.05)	-0.017*** (0.05)	-0.724** (0.05)	-0.081*** (0.00)
Farm located in Basin and Range region *(BASINR)*	-0.051 (0.03)	-0.008*** (0.00)	-	-	-	-
Year dummy for 2004 *(Y04)*	-0.043*** (0.02)	-0.007*** (0.00)	-0.008 (0.04)	-0.001 (0.00)	0.026** (0.02)	0.004** (0.00)
Year dummy for 2005 (Y05)	-0.050*** (0.02)	-0.008*** (0.00)	0.081*** (0.04)	0.006*** (0.00)	-0.005 (0.02)	-0.001 (0.00)
Log pseudo-likelihood	-4824.8		-2781.2		-4431.2	
Pseudo R^2	0.33		0.24		0.47	
Sample Size	19,638		19,638		19,638	

Numbers in parentheses are p-values. Single, double, and triple asterisks indicate statistical significance at 10%, 5%, and 1% levels respectively.

Table 2: Regression Estimates of farm profitability of Young and Beginning Farmers (2004 to 2006), selected quantiles

Variables	ROA[1]		
	Q20	**Q50**	**Q90**
Intercept	0.020*** (0.01)	0.019*** (0.01)	0.063*** (0.01)
Predicted value of share of GM corn acres *(PGMCRNACRS)*	-0.0003 (0.00)	-0.013*** (0.01)	-0.007*** (0.00)
Predicted value of share of GM cotton acres *(PGMCTNACRS)*	-0.0001 (0.00)	0.001*** (0.00)	0.002* (0.00)
Predicted value of share of GM soybean acres *(PGMSYBNACRS)*	0.0002 (0.00)	-0.002 (0.00)	0.0002 (0.00)
Government Payments *(GOVTPMT)*	0.000 (0.00)	-0.004* (0.00)	-0.004*** (0.00)
Farming operations use computers *(COMP)*	-0.001 (0.02)	-0.023* (0.01)	-0.004*** (0.00)
Farming operations use business plan *(MGMT)*	-0.001 (0.02)	-0.006 (0.00)	-0.002 (0.00)
Number of decision makers in farm *(NUM_DECIS)*	0.000 (0.00)	0.003*** (0.00)	0.004*** (0.00)
Operator's education *(EDUC)*	0.000 (0.00)	-0.0004*** (0.00)	-0.001*** (0.00)
Operator works off farm *(H_OFFOP)*	0.000 (0.00)	0.000* (0.00)	0.000 (0.00)
Operator's spouse works off farm *(H_OFFSP)*	0.000 (0.00)	0.000* (0.00)	0.000 (0.00)
Farm size dummy *(SMALL_2)*	0.000 (0.00)	0.001*** (0.00)	-0.007*** (0.00)
Farm size dummy *(SMALL_3)*	0.000 (0.01)	0.002** (0.00)	-0.005*** (0.00)
Farm size dummy *(SMALL_4)*	0.000 (0.01)	0.000*** (0.00)	-0.006* (0.00)
Farm size dummy *(SMALL_5)*	-0.001 (0.04)	-0.017* (0.01)	0.009** (0.00)
Sale more than $500,000 *(LARGE)*	-0.002 (0.07)	0.057** (0.03)	0.014*** (0.00)
Ratio of farm debt to farm assets *(ADARAT2)*	0.060 (0.30)	0.692** (0.32)	0.692*** (0.28)
Year dummy for 2004 *(Y04)*	0.000 (0.00)	-0.002 (0.00)	0.003 (0.00)
Year dummy for 2005 (Y05)	-0.001 (0.00)	-0.006*** (0.00)	-0.020*** (0.00)
Pseudo R^2	0.048	0.380	0.864
Sample Size	19,638	19,638	19,638

Numbers in parentheses are p-values. Single, double, and triple asterisks indicate statistical significance at 10%, 5%, and 1% levels respectively. [1] ROA is defined as the ratio of net farm income to total farm assets.