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The influence of GM crop adoption on the profitability of farms operated by young and beginning farmers

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Abstract

Purpose – The purpose of this paper is to assess the impacts of GM crop adoption on the profitability of farms operated by young and/or beginning farmers and ranchers (YBFR).

Design/methodology/approach – This research uses weighted quantile regression analysis in conjunction with 2004-2006 Agricultural Resource Management Survey to evaluate the impact of GM crop adoption on financial performance of farms operated by YBFR. The methodology employed in this study corrects for the simultaneity of technology adoption and farm financial performance.

Findings – As expected, the impact of GM crop adoption on profitability is positively affected by the scale of operation and leverage. On the other hand, off-farm employment by "beginning" farmers has a negative impact on farm's profitability if they choose to adopt GM crops. Finally, quantile regression results from a farm household study shows that the model performs better at the higher quantile of the distribution.

Research limitations/implications – This study helps to determine whether the adoption of GM crops increases the profitability of farms operated by "beginning" farmers. In addition, it explores the impact of other factors (such as farm, operator, demographic, and financial characteristics) on the profitability of farms operated by "beginning" farmers.

Practical implications – Computing the profitability of adoption decisions for YBFR will provide significant information to YBFR that they can use in constructing their farm operations strategic business plan and future decisions regarding farming operations.

Originality/value – Existing research does not examine the impact of GM crops adoption on farm profitability of YBFR. Furthermore, YBFR operators face significant challenges in making their operations financially viable, owing to lack of access to capital and land.

Keywords United States of America, Farms, Crops, Profit, Genetic modification

Paper type Research paper

Introduction

A 2009 report by the USDA estimates that young and beginning farmers and ranchers (YBFR) operate approximately one-fifth of all US farms and these operators face significant challenges in making their operations financially viable (Ahearn and Newton, 2009). Consequently, it is essential for YBFR to acquire good information

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about farming techniques, managing a farm business, adhering to regulations, minimizing production costs, and adopting new technologies in order to ensure long-term profitability of their operation (Baker and Klien, 2009). A young or beginning farmer/rancher, as defined by the Farm Service Agency (FSA), is an individual or entity that has not operated a farm or ranch for more than ten years and who will materially and substantially participate in the operation of the farm. Moreover, YBFR have different needs than established farmers; for example, the scale of their operation is often insufficient to make profits; they lack experience in farming operations and farm management decisions; and they often face high land values and production costs (Mishra *et al.*, 2009).

The adoption of technology in production agriculture includes genetically modified (GM) crops, pest and insect resistant crops, and precision farming. The adoption of these technologies provides for cropping and production efficiency gains. Moreover, US farmers have steadily increased their farming of GM crops because these efficiency gains translate into increasing farm profitability and reducing yield risk (Brookes and Barfoot, 2006; Alston *et al.*, 2002).

Existing research does not examine the impact that adoption of GM crops by YBFR has on the profitability of their farm operations. It is likely that the decision to adopt is jointly determined with the measure of profitability, i.e. the adoption of GM crops should have a positive impact upon the farm's return on assets (ROA), a widely used measure of profitability that tells the farm operator how efficiently he is using his assets to generate income (Barry *et al.*, 1995).

In addition, YBFR are likely to have different attributes and skills than established farm operators, and these attributes and skills will influence both adoption rates and the profitability of these adoptions. For example, YBFR are more likely to have more education, work off the farm, and are more receptive to adopting new technology such as GM crops (Mishra *et al.*, 2002). They adopt GM crops with the expectation that GM crops will reduce farming time and potentially increase their availability to work off-farm. Moreover, YBFR are likely less certain about the benefits and risks associated with the adoption of crops into their cropping operation than non-YBFR, uncertainty that might make them hesitant to adopting (Baerenklau, 2005). YBFR also face the problem of having the requisite skills that are acquired from learning by doing and learning from others, which could influence the profitability of adoption (Marra *et al.*, 2003; Abadi Ghadim *et al.*, 2005; Baerenklau, 2005).

The overriding objective of this study is to assess the impacts of GM crop adoption on the profitability of farms operated by YBFR. This study will help to determine whether the adoption of GM crops increases the profitability of farms operated by YBFR. In addition, this study will also explore the impact of other factors (such as farm, operator, demographic, and financial characteristics) on the profitability of farms operated by YBFR. Because of the heterogeneity in farm operations, we investigate the impact of adoption of GM crops over the entire farm profitability distribution using quantile regression. That is, whether or not the effect of adopting GM crops on farm profitability similar across all YBFR. Computing the profitability of these decisions for YBFR will provide significant information to YBFR that they can use in constructing their farm operations' strategic business plan and in future decisions regarding farming operations.

Literature review

GM crop adoption

Some of the major GM crops grown in the USA are transgenic corn and cotton modified to express insecticidal proteins from the soil bacterium *Bacillus thurgiensis* (Bt), and herbicide tolerant (HT) soybean. *Bt* corn has been demonstrated to provide satisfactory control of a range of Lepidopteran pests including stalk boring caterpillar complex (Hammond *et al.*, 2009). *Bt* cotton helps control tobacco budworm, bollworm, and pink bollworm (Fernandez-Cornejo, 2007). HT soybeans, commonly known as Roundup-Ready® soybeans, are soybeans which have been modified to be highly resistant to the broad spectrum herbicide, glyphosate, allowing farmers to control weeds more effectively but with smaller amounts of less toxic and less persistent pesticides (Goklany, 2007). Adoption of these new plant varieties in production agriculture in both the USA and across the globe is occurring at a rapid pace. In the USA, for example, adoption of HT account for 91 percent of soybean acreage in 2007, while *Bt* cotton was planted on 59 percent of the 2007 US cotton acreage in 2007 and *Bt* corn was planted on 49 percent of the 2007 US corn acreage (Fernandez-Cornejo, 2007).

Non-pecuniary benefits of GM crop adoption

A key non-pecuniary benefit associated with the cultivation of HT GM crops is the simplification of the weed management process (Carpenter and Gianessi, 2001; Bullock and Nitsi, 2001; Alexander, 2006). Cultivation of non-HT crops requires the application of multiple herbicides to control weeds, while weed control can be accomplished in HT crops with one herbicide. Using Agricultural Resource Management Survey (ARMS) data, Fernandez-Cornejo and Caswell (2006) indicate the adoption of GM crops is likely to occur because adoption allows the farm operator to increase flexibility and time for other activities. This is especially true for HT soybeans where profits are not statistically higher than conventional beans. Thus, the attraction to adopt HT soybeans, for many farmers, stems from increased free time for other activities, easier weed control, and greater flexibility advantages that are difficult to quantify monetarily. In addition, Alston *et al.* (2002) in their *ex ante* analysis on the adoption of *Bt* corn found that farmers would be willing to pay an average of $4.18 per acre for the timesaving and risk reduction associated with the adoption of *Bt* corn. Fernandez-Cornejo *et al.* (2005), Fernandez-Cornejo and Caswell (2006) both note that that the adoption of GM crops is directly related to increased off-farm income. Consequently, if YBFR were reluctant to try traditional and time-consuming farming processes using older technologies, they would be more likely to adopt new and innovative technologies, such as GM crops, which reduce the time required to spend farming.

Financial benefits of GM crop adoption

Fernandez-Cornejo and Caswell (2006), indicate that a majority of farmers adopt GM crops to improve yield, which in turn makes their operations more profitable. Published research on the financial impacts of using GM crops especially HT soybeans, however, has been mixed. Roberts *et al.* (1999) used field trials in West Tennessee to conduct an economic analysis of HT soybeans. The authors concluded that returns from of HT soybean system were higher than other herbicide systems on conventionally tilled because of both better yields and lower herbicide costs. Research from experimental trials in Mississippi showed higher yields and net returns from HT soybeans versus conventional soybean varieties (Arnold *et al.*, 1998). A comparison of costs and returns with regard to HT and conventional soybean varieties in Kentucky, however, did not show a significant difference in returns above seed, herbicide, and fixed costs (Ferrell *et al.*, 1999). Using the 1997 national survey of soybean producers, Fernandez-Cornejo *et al.* (2000), using the same data but controlling for cropping practices, agronomic conditions, and producer attributes also found no statistical significance in the rate of returns between farmers who adopted a HT soybean variety over a conventional variety. Further research from Fernandez-Cornejo *et al.* (2002) also shows no significant increase in the profits of farm operations that adopted HT soybeans in the US when compared to non-adopters, even though there were yield increases.

In surveying the literature, Marra (2001) and Marra *et al.* (2002) conclude that growing *Bt* cotton is more likely than not to be a relatively profitable enterprise in most of the US Cotton Belt. In addition, the aforementioned research shows growing *Bt* corn will provide a small but significant yield increase in most years across the Corn Belt, which will result in significant increases in profit. This research is supported more recently by the work of Fernandez-Cornejo and Caswell (2006) that state the adoption of insect-resistant cotton and corn when pest infestations were more prevalent has led to increased profitability in those operations that have adopted.

Empirical framework and procedure

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

$$\begin{gathered}\text{Max}\,\Pi = \left[\sum \mathrm{P_i} Q_i(k, P_i, I, \theta)\right] - \left[\sum \mathrm{C}_j(Q_j, x_j, L, \omega_j, \theta)\right] \\ \text{s.t.}\quad g_j(x_j) \leq X_j \quad j = 1, 2 \ldots n. \\ \mathrm{I_t} = f(A, H) \\ L = L_\mathrm{o} + L_h \end{gathered} \tag{1}$$

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 also depends on the farm operator's level of human capital (education and experience) k, price of output, various farm characteristics I, and managerial ability θ. On the cost side, 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 ω_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 (measured as acres in GM crops); A represents operator's access to information regarding GM crop technology (such as farm management consultants, internet access, county agents, etc.); H is operator's human capital endowments defined by age, education, and experience.

Profits for the farm can be measured by net farm income. Since our data are cross-sectional, we assume that all farmers face the same fixed output prices 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, is a binary vector denoting the adoption of GM crops (i.e. $G = 1$ if technology adoption occurs, 0 otherwise); Z, is a matrix of variables affecting the adoption of GM crops; and ϵ_1 and ϵ_2 are vectors of errors.

We then replace the dependent variable (NFI) in equation (2) with ROA, which measures the overall return on the farm's assets, inclusive of financial leverage and taxes. ROA is a widely used profitability ratio in both the farm management literature and in the corporate finance literature (Gloy *et al.*, 2002; Gloy and LaDue, 2003; Ross *et al.*, 2007; Hyde *et al.*, 2008; Mishra *et al.*, 2009). ROA is calculated as:

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

where Net Farm Income is the accrual net farm income and Total Farm Assets is the value of farm assets in 2005. The benefit of using ROA as opposed to the absolute Net Farm Income is that it avoids the problems of comparing farm operations of different sizes (Ross *et al.*, 2007). It would be almost impossible to compare directly the Net Farm Incomes of a cow-calf operation in Kentucky to a grain farm in Iowa, which is why ROA is a more appropriate measure for farm profitability.

The independent variables hypothesized to affect the farm's profitability are:

- 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 influences productivity and/or cost of production, which in turn affects net returns. YBFRs will choose to adopt and plant GM crops, if the expected profits of doing so exceed the specified threshold profits, which could be interpreted as the expected returns of non-adoption plus a premium for switching to a new technology (Burrows, 1983). Following Amemiya (1981) and Maddala (1983), equation (2) could be considered as reduced form equation through the exclusion of ROA from Z. For a single equation econometric model, the parameter coefficients are generally estimated as:

$$\hat{\beta} = \min_{\beta \in R^P} \sum \left(y_i - x_i^{'} \beta \right)^2 \tag{4}$$

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

While OLS has the primary goal of determining the conditional mean of random variable Y, given some explanatory variable x_i, $E[Y|x_i]$, quantile regression goes beyond this and enables us to pose the same question at any quantile of the conditional distribution function. Furthermore, quantile regression focuses on the interrelationship between a dependent variable and its explanatory variables for a given quantile. Quantile regression also overcomes various problems of OLS especially when error terms are not constant across a distribution, a violation of the axiom of homoscedasticity. Moreover, by focusing on the mean as a measure of location, information about the tails of a distribution are lost with OLS, but not with quantile regression. Finally, OLS is sensitive to extreme outliers, which can significantly distort results, meaning a policy based upon an OLS analysis might yield undesirable results. Consequently, the single equation econometric model can be extended to quantile regression (see Koenker and Bassett (1978, 1982) for details about quantile regression) to examine the changes in coefficients across the distribution of the endogenous model. As Hennings and Katchova (2005) note, the same management strategy employed by two different YBFR operations will have differing effects if the operations are at different points in the ROA distribution. For example, the adoption of GM crops by a YBFR into his/her operation's crop rotation will influence profitability differently given the heterogeneity in the farm sector. Even though the OLS estimates obtained in equation (4) would be consistent, they would be inefficient because they are based on the population mean, which is not necessarily indicative of the magnitude and nature of those effects at different locations in the ROA distribution for YBFR (Koenker and Hallock, 2001). Thus, the quantile regression provides estimates of parameter coefficients across the entire population and tests whether or not these differences are statistically significant. This allows a more complete picture to emerge with respect to the effect of GM crop adoption on the profitability of farms operated by YBFR. The quantile regression can be represented as:

$$\hat{\beta}(\tau) = \min_{\beta \in R^{P}} \sum_{i=1}^{n} \tau\left(y_i - x_i'\beta\right)^2 \textit{ for any quantile}, \quad \tau \in (0,1)$$

or

$$\hat{\beta}(\tau) = \min_{\beta \in R^{P}} \left[\sum_{i \in \left\{ i: y_i \geq x_i'\beta \right\}} \tau \left| y_i - x_i'\beta \right| + \sum_{i \in \left\{ i: y_i \leq x_i'\beta \right\}} (1-\tau) \left| y_i - x_i'\beta \right| \right] \tag{5}$$

We use the quantile regression defined in equation (5) as the basis for our empirical model presented here following a reduced-form methodology that uses general predictions from the economic model outlined above to guide the empirical work. In this paper, the quantile model can be specified as:

$$Q_\theta[y|\mathbf{X}] = \alpha_\theta + \mathbf{X}B_\theta \tag{6}$$

where y is ROA, $Q_\theta[y|\mathbf{X}]$ is the θth quantile of y conditional on covariate matrix, $\mathbf{X}$, that includes farm, operator, and predicted values of share of acreage in GM corn, GM cotton, and GM soybean; along with other financial, off-farm work, and farm size variables; and the coefficient β_θ represents the returns to covariates at the θth quantile.

Data

Data for this analysis are from the 2004-2006 ARMS. The Economic Research Service and the National Agricultural Statistics Service conduct ARMS annually. 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 2004-2006 ARMS collected information on farm households in addition to farm business data. For example, the survey collected detailed information on off-farm hours worked by both 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. Questions pertaining to off-farm employment of operators and spouses allows for the examination of whether the farm household has an alternate goal to generating maximum household income for the farm business operation. In addition, questions about income received from other sources, such as disability, social security, and unemployment payments, and gross income from interest and dividends were asked. The 2004-2006 ARMS contains a sample of 2,860 US farms that can be classified as YBFR.

Because the ARMS data has a complex survey design and is cross-sectional, it raises the possibility that the error terms in both logistic models are heteroskedastic. Accordingly, all standard errors were adjusted for heteroskedasticity using the Huber-White sandwich robust variance estimator based on algorithms contained in STATA (Huber, 1967; White, 1980). Further, this type of adjustment for standard errors was used in the regression models in lieu of the Jackknife variance estimation method when a subset of the main dataset is analyzed (Mishra and El-Osta, 2007).

Variable description

The two subsections in this section provide the rational for why a particular variable is included as an explanatory variable. Summary statistics for the variables used in the analysis are presented in Table I. The first subsection discusses those variables, which are related to technology adoption, and the second subsection examines those variables that are likely to influence farm financial performance.

Variables related to technology adoption

Farm operator characteristic that are known to affect the production function of the farm business, such as education, experience and other demographic variables, are also known to influence technology adoption (Huffman, 1977; Lins *et al.*, 1987). Feder *et al.* (1985) postulated that the adoption of GM crops is more likely occurring by younger farmers who are often more highly educated than their peers. Research

Table I.
Definition of independent variables and summary statistics

Variables	Beginning farmers Mean	Beginning farmers SD	Young farmers Mean	Young farmers SD
Operator's off farm work experience in years (OPOWKEXP)[a]	3.9524	7.98822	2.2187	4.6932
Operator's age (EDUC)[a,b]	13.211	1.78946	13.243	1.8083
Operator's education in years (AGE)[a]	45.292	12.434	34.81	4.4767
Operator's age squared (AGESQ)[a]	2205.9	1205.99	1231.7	294.53
Operator works off farm in hours (H_OFFOP)[b]	80.31	88.6491	61.809	83.659
Operator's spouse works off farm in hours (H_OFFSP)[b]	73.679	82.3204	71.709	79.156
Computers = 1 if the farming operation uses computers; 0 otherwise (COMP)[b]	0.1122	0.31571	0.1448	0.352
Management = 1 if the farming operations uses a business plan; 0 otherwise (MGMT)[b]	0.0636	0.24415	0.0659	0.2482
Number of decision makers in the farm operation (NUM_DECIS)[b]	1.5902	0.83508	1.5826	0.849
Government payments = 1, if the farm receives government payments (GOVTPMT)[b]	0.1545	0.36153	0.1936	0.3952
Farm size = 1 if farm sales are more than \$500,000; 0 otherwise (LARGE)[a,b]	0.3105	0.46278	0.4786	0.4997
Cropping efficiency (ratio of gross cash farm income to total variable costs) (CROP_EFF)[a]	2.2306	8.67811	2.1276	3.5487
Risk aversion (ratio of crop/livestock insurance premiums to total variable cost) (R_AVERSION)[a]	0.007	0.02637	0.013	0.032
Tenant = 1 if farm operator is tenant; 0 otherwise (TENANT)[a]	0.1598	0.36648	0.2219	0.4156
Part-owner = 1 if farm operator is part-owner; 0 otherwise (POWNER)[a]	0.2951	0.45617	0.4369	0.4961
Mean productivity index (MEANPI)[a]	78.613	6.60365	78.903	6.0861
Farm is cash grain = 1 if farm is classified as cash grain; 0 otherwise (CGRAIN)[a]	0.1294	0.33567	0.214	0.4102
Farm's debt-to-asset ratio (ADARAT)[a,b]	0.254	1.5476	0.3363	2.0653
Heartland region = 1 if the farm is located in the Heartland region; 0 otherwise (HEART)[a]	0.1094	0.31225	0.1732	0.3785
Northern crescent region = 1 if the farm is located in the northern crescent region; 0 otherwise (NORTHC)[a]	0.1444	0.35156	0.1588	0.3656
Northern great plains region = 1 if the farm is located in the northern great plains region; 0 otherwise (NORTHGP)[a]	0.0462	0.20985	0.059	0.2356
Prairie gateway region = 1 if the farm is located in the prairie gateway region; 0 otherwise (PGATE)[a]	0.1084	0.31093	0.1096	0.3124
Eastern uplands region = 1 if the farm is located in the eastern upland region; 0 otherwise (EUPLAND)[a]	0.1094	0.31225	0.098	0.2973
Southern seaboard region = 1 if the farm is located in the heartland region; 0 otherwise (SSBOARD)[a]	0.1622	0.36873	0.1314	0.3379
Fruitful rim region = 1 if the farm is located in the fruitful region; 0 otherwise (FRIM)[a]	0.1759	0.38078	0.137	0.3439
Basin and range region = 1 if the farm is located in the basin and range region; 0 otherwise (BASINR)[a]	0.0678	0.2515	0.045	0.2074
Mississippi portal region = 1 if the farm is located in the Mississippi portal region; 0 otherwise (MPORTAL)[a]	0.0762	0.2654	0.0882	0.2837

(*continued*)

Variables	Beginning farmers Mean	 SD	Young farmers Mean	 SD
Share of GM corn acres to total acres operated (%)[b]	0.0834	0.25929	0.1572	0.3311
Share of GM cotton acres to total acres operated (%)[b]	0.0277	0.15957	0.055	0.2219
Share of GM soybean acres to total acres operated (%)[b]	0.1107	0.31263	0.21	0.4038
2004 = 1 if the year is 2004; 0 otherwise (Y04)[a,b]				
2005 = 1 if the year is 2005; 0 otherwise (Y05)[a,b]	0.1107	0.31263	0.21	0.4038
Sample size	2,860		2,154	

Notes: [a]Variables used in the adoption model; [b]variables used in the profitability model

Table I.

conducted by van Scharrel (2003), Payne *et al.* (2003), Alexander *et al.* (2003) and Erlinda *et al.* (2007) shows that farmer age was negatively associated with adoption of GM crops, i.e. a younger farmer was more likely to adopt GM crops into his crop rotation than an older farmer was. Darr and Chern (2002) found that if a farm operator had at least some college education, he was more likely to adopt both GM corn and soybeans reinforcing the postulation on education. In addition, most other studies including Hubbell *et al.* (2002), Fernandez-Cornejo *et al.* (2001, 2002), Fernandez-Cornejo and McBride (2002) and Qaim and de Janvry (2003), have found that the adoption of GM crops is positively related to educational level of farm operators. Since YBFR and their spouses are typically more educated than their peers are, it makes them more likely to seek higher paying jobs outside the farming business as pointed out by Mishra *et al.* (2002); the adoption of GM crops should be related to off-farm work experience. GM crop adoption provides greater flexibility in time management, allowing YBFR to seek additional income from off-farm activities (Fernandez-Cornejo and Caswell, 2006).

Following Goodwin and Mishra (2004), we utilize a measure of efficiency for the farm operation (CROP_EFF) which is the ratio of gross cash farm income to total variable costs. Efficiency is proxy for farm management ability, i.e. the ability to generate more farm income with the same amount of variable costs. We also use the ratio of crop/livestock insurance premiums paid to total variable cost as a proxy for risk aversion (R_AVERSION). As the share of crop/livestock, insurance premiums as part of total variable costs increases, the higher the risk aversion for the farm operator. The use of insurance indicates that the farm operator is willing to give up some revenue (the cost of the insurance) in order to guarantee a certain level of revenue in the farm operation. The greater the guaranteed level of return the higher the insurance premium, i.e. farmers who have higher insurance premiums as a share of total variable cost are willing to pay more to ensure a known revenue stream in their operation.

Variables related to profitability

With regard to factors affecting financial performance in general, Fox *et al.* (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/characteristics, demographics, and goals were important in explaining profitability differences across farms.

First, education (EDUC) is hypothesized to have a positive effect on financial performance, as predicted by human capital theory (Becker, 1975; Delaney and Huselid, 1996; Bontis and Fitzenz, 2002; Youndt *et al.*, 2004; Shrader and Siegel, 2007). Consequently, better-educated farmers tend to have farm operations that have a higher ROA and/or seek off-farm employment that is more profitable than their peers who work solely on the farm.

Recent results on the effects of age as an explanatory variable for financial performance have been mixed. Davis *et al.* (2009) and Hyde *et al.* (2008), found age to influence financial performance negatively, but studies by Tauer and Mishra (2006) and Mishra *et al.* (2009), found age positively influences farm profitability. In this study, we also use age of the operator as an explanatory variable that potentially reflects farming experience. Furthermore, we also incorporate educational level of the farm operator. Both of these factors have the potential for affecting the 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 time allocated to the farm operation. 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 to lower performance of the farm.

Farm size is another factor related to profitability (Matulich, 1978; Kauffman and Tauer, 1986; Haden and Johnson, 1989; Sonka *et al.*, 1989; Boessen *et al.*, 1990; Ford and Shonkwiler, 1994). 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 (1996) indicated that well-managed farms, based on farm records, are better able to compete on per-unit profitability basis with farms many times larger. In our study, we use three different variables to measure the impact of managerial ability on profitability of YBFR. The first variable, business plan (MGMT) is used as a dummy variable to study the impact of having a written business plan on the profitability of the farms owned/operated by YBFR. Since business plans are an essential part of any business because they act as road maps for the future direction of the farm operation, it is hypothesized to have a positive impact on ROA. We also assume that keeping computerized books and records (COMP) is a good proxy for managerial ability. The notion that farmers who keep computerized records of income and expenditures (bookkeeping) are more likely to keep track of their income and expenses (Mishra *et al.*, 1999) and are able make sound farming decisions. Finally, we expect that the number of decision makers on the farm (NUM_DECIS), will have a positive impact on the profitability of adoption (Mishra *et al.*, 2009).

Results

Impact on farm profitability

The parameter estimates for the adoption-impact model (equation (4)) for "beginning" farmers on financial performance obtained in STATA are presented in Table II. Because of brevity and significance of coefficient across various quantiles, we present results for only the 0.2, 0.5, 0.7, 0.8, and 0.9 quantiles. The coefficients are statistically significant across these quantiles. The pseudo-R^2 in Table II increases with the

Table II. ROA regression estimates for beginning farmers and ranchers at selected quantiles

Variables	ROA^a Q20		Q50		Q70		Q80		Q90	
Intercept	−0.0343	(0.0232)	0.0215	(0.0154)	0.0264	(0.0198)	0.0505**	(0.025)	0.1285**	(0.0581)
Predicted value of share of GM corn acres (PGMCRNACRS)^b	0.0052*	(0.0031)	−0.0006	(0.0024)	−0.0043	(0.0029)	−0.0072**	(0.0035)	−0.007	(0.0058)
Predicted value of share of GM cotton acres (PGMCTNACRS)^b	−0.0021**	(0.0009)	−0.001*	(0.0006)	−0.0007	(0.0007)	0.0003	(0.0008)	0.0005	(0.0014)
Predicted value of share of GM soybean acres (PGMSYBNACRS)^b	−0.0006	(0.0004)	0.0007**	(0.0003)	0.0012***	(0.0004)	0.0018***	(0.0005)	0.002**	(0.0008)
Government payments (GOVTPMT)	−0.001	(0.0083)	0.0045	(0.0051)	−0.0008	(0.0071)	−0.0032	(0.0096)	−0.0167	(0.0146)
Farming operations use computers (COMP)	0.0014	(0.0072)	0.0049	(0.0069)	0.0028	(0.0096)	0.0068	(0.0128)	0.0234	(0.0365)
Farming operations use business plan (MGMT)	−0.0104	(0.0109)	−0.0046	(0.0076)	−0.0074	(0.0101)	−0.0135	(0.011)	−0.0353**	(0.0168)
Number of decision makers in farm (NUM_DECIS)	−0.0057	(0.006)	−0.0051	(0.0033)	−0.0024	(0.0033)	−0.0036	(0.0035)	−0.0025	(0.0066)
Operator's education (EDUC)	0.0005	(0.0013)	−0.0002	(0.0009)	0.0013	(0.0012)	0.0023	(0.0016)	−0.0007	(0.0029)
Operator works off farm (H_OFFOP)	−0.0001	(0.0001)	−0.0001	(0.0001)	−0.0001**	(0.0001)	−0.0001*	(0.0001)	−0.0002**	(0.0001)
Operator's spouse works off farm (H_OFFSP)	−0.0001	(0.0001)	−0.0001	(0.0001)	−0.0001	(0.0001)	−0.0001	(0.0001)	−0.0001	(0.0001)
Farm size dummy (SMALL_2)	−0.0032	(0.0095)	0.0079	(0.0051)	0.0052	(0.0083)	0.0034	(0.0113)	0.0142	(0.0316)
Farm size dummy (SMALL_3)	−0.0063	(0.0083)	0.0005	(0.0053)	−0.0004	(0.0086)	−0.0049	(0.0102)	0.0071	(0.0289)
Farm size dummy (SMALL_4)	−0.0085	(0.0087)	0.0002	(0.0056)	0.0014	(0.0078)	−0.0063	(0.01)	−0.011	(0.0293)
Farm size dummy (SMALL_5)	0.0213**	(0.0107)	0.0389***	(0.0147)	0.041	(0.0329)	0.0921**	(0.0404)	0.1417**	(0.0653)
Sale more than $500,000 (LARGE)	0.0224**	(0.0101)	0.0532***	(0.0178)	0.0528**	(0.0257)	0.0832**	(0.0328)	0.1142*	(0.0615)
Farm debt to farm assets ratio (ADARAT)	−0.0545	(0.0443)	0.0211	(0.0858)	0.3305	(0.2278)	0.4015	(0.4356)	1.2959**	(0.5383)
Year dummy for 2004 (Y04)	0.0089	(0.006)	0.0035	(0.0044)	0.0024	(0.0068)	0.007	(0.0086)	−0.0058	(0.0113)
Year dummy for 2005 (Y05)	−0.0033	(0.0054)	0.0041	(0.004)	0.0064	(0.0057)	0.0084	(0.008)	0.0015	(0.0127)
Pseudo R^2	0.0136		0.0262		0.0775		0.1447		0.2799	
Sample size					2,800					

Notes: Significance at: *10, **5 and ***1 percent; ^{a}ROA is defined as the ratio of net farm income to total farm assets; ^{b}the predicted value of share of GM corn acres (PGMCRNACRS); share of GM cotton acres (PGMCTNACRS), and share of GM soybean acres (PGMSYBNACRS) are obtained from an adoption-model (equation (2)). Heckman's technique indicated that there was no self-selection present in the model; further, the McFadden's pseudo-R^2 for the estimated models, indicate reasonable explanatory power; in the interest of brevity, we will only present results of the profitability model; however, results of the adoption model are available from the authors upon request; numbers in parentheses are standard errors quantile, i.e. the fit for the 0.2 quantile was not as good as it was for the 0.9 quantile. The significance of GM crop adoption by "beginning" farm operators' on profitability varied by both the quantile and crop. For example, adoption of GM corn decreased farm profitability (ROA) by 0.7 percent in the 0.8 quantile while increasing profitability by about 0.5 percent in the 0.2 quantile. When looking at the adoption of GM cotton by YBFR decreased ROA by a small percentage (0.2 and 0.1 percent for 0.2 and 0.5 quantiles). While these results may seem counter-intuitive at first, there are some plausible reasons for these results. For the *Bt* corn and *Bt* cotton varieties, the pests that are controlled with the *Bt* gene are more damaging to the cotton plant than the corn plant. Thus, the yield loss for an acre of cotton that suffers from a pest infestation, which could have otherwise been controlled by using a *Bt* cotton variety, is typically greater than the yield loss that would have been observed for corn (Carpenter and Gianessi, 2001). Therefore, from the farm operator's perspective, using *Bt* cotton is much more of a necessity to ensure profitability of the operation. The "beginning" farmers at the lower two quantiles are already operating poorly performing farms, thus they must adopt *Bt* cotton in an attempt to remain viable irrespective of the cost associated with the adoption of *Bt* cotton. Our results are consistent with the finding of McBride and El-Osta (2002), who found that adoption of *Bt* corn (for upper quantiles) decreased crop-operating margins.

With respect to HT soybeans, adoption has a positive and significant effect for all but the 0.2 quantile. It is likely that once the farm operator introduces a HT crop such as HT soybeans into their cropping rotations, he/she realizes the positive impact adoption of HT crops can have on the viability of their operation. Once, they do this they typically want as many of their field crops to be HT as possible. This phenomenon occurs because operators worry about herbicide burn, i.e. those crops not HT will somehow be exposed to the Roundup chemical and the entire crop will be lost or there will be a substantial reduction in yield. Consequently, to prevent this from occurring, farmers are more likely to plant HT varieties of crops that they otherwise would not plant, which likely increases the cost of the seed for their operation, but also reduces pesticide costs and reduces yield variability.

The coefficient on the use of a management plan (MGMT) is negative and statistically significant at the 1 percent level for the 0.9 quantile. Specifically, results indicate that the use of a management plan decreases ROA by 3.5 percent at the 0.9 quantile. This finding at first is somewhat surprising since one would assume adoption of a management plan would increase farm profitability. This result may imply that, considering the nature of these crops (homogenous commodities) strategic planning is not as beneficial as it would be for differentiated agricultural products. Furthermore, a "beginning" farmers whose operation is already in the top 10 percent of profitability is likely doing all they can do to maximize profit, and time spent writing a business plan takes away from profit generating activities.

The coefficient on the farm operators' working off farm (H_OFFOP) is negative and statistically significant at the 1 percent level of significance for the 0.7, 0.8, and 0.9 quantiles. The magnitude of the impact, however, is highest at the 90th percentile. Specifically, results indicate that working off farm decreased ROA by 0.01 percent in the 70th percentile and about 0.2 percent for "beginning" farmers in 0.9 quantile. This finding is not surprising, because as the farm operation becomes more profitable a "beginning" farmer would have less of an incentive to seek work off the farm.

This result may imply beginning farmers are likely to get higher returns to human capital from on-farm work, than off farm work, and if they take an off-farm job, it will likely have a negative impact on the farm's financial performance (ROA).

Results in Table II also indicate that farms which have sales that exceed $500,000 (LARGE) have higher financial performance at all quantiles; and the magnitude of the impact increases by quantile. These results are consistent with the findings of Ford and Shonkwiler (1994), Haden and Johnson (1989), El-Osta and Johnson (1998), and Mishra *et al.* (1999) who suggest economies of scale have a significant impact on farm financial performance. Finally, results in Table II indicate that "beginning" farm operators with higher debt-to-asset ratios, for the 0.9 quintile, have better financial performance. This result at first seems counterintuitive; there are some logical explanations for this result. First, these "beginning" farmers, who have a high debt-to-asset ratio, have likely made a commitment to the farm operation as their main source of income and are using debt to make their operation economically viable, i.e. the purchasing of farmland to expand the operation and/or making investments in new technologies that make the operation more profitable. In addition, "beginning" farmers tend to locate near metro areas where farmland is scarce and costly relative to non-metro areas. "Beginning" farmers are drawn to metro areas because of the opportunities for acquiring high paying off-farm jobs (Ahearn and Newton, 2009).

During initial reviews of the paper, the question was raised if differences would arise when comparing only "young" farmers – less than 40 years in age and farming experience of less than ten years and FSAs definition of "beginning" farmers – an individual or entity that has not operated a farm or ranch for more than ten years and who will materially and substantially participate in the operation of the farm. The parameter estimates for the adoption-impact model (equation (4)) for the "young" farmer group only financial performance are presented in Table III. As with the results for "beginning" farmers, we only present the results for the 0.2, 0.5, 0.7, 0.8, and 0.9 quantiles in both cases.

A similar pattern is seen with the significance of GM crop adoption for "young" farmers as was observed by "beginning" farmers on their farm's profitability with variation by both quantile and crop. Adoption of GM corn instead of only decreasing farm profitability at the 0.8 quantile also decreases profitability at the 0.9 quantile. Adoption of GM cotton by "young" farmers decreased ROA by a small percentage for only the 0.2 quantile. Unlike "beginning" farmers, there was a positive significant impact on cotton adoption for the 0.8 and 0.9 quantile. The difference is likely the result of a "young" farmer, one who is probably raised on the farm, only willing take over and/or buy into a farm operation that has an established record of sustained and high profitability (likely the combination of a multitude factors including high yielding fields, necessary equipment, established contracts, etc.). With respect to HT soybeans, adoption has a positive and significant effect for all but the 0.2 and 0.4 quantile, a similar pattern to "beginning" farmers. The sizes of the impacts were larger for each quantile (0.7, 0.8, and 0.9) for the "young" farmers group when compared to the "beginning" farmers group. This is likely a reflection of the "young" farmer group having more knowledge of and understanding of the risks of using HT soybeans in their crop rotation relative to "beginning" farmers.

Similarly, to the "beginning" farmers group, "young" farmers who are in the 0.9 quintile can increase the profitability of their operation with debt (ADARAT).

Table III.
ROA regression estimates for young farmers and ranchers for selected quantiles

Variables	ROA^{a} Q20		Q50		Q70		Q80		Q90	
Intercept	−0.0241	(0.0663)	−0.0081	(0.0749)	0.0655	(0.0717)	0.051	(0.0595)	0.0544	(0.2169)
Predicted value of share of GM corn acres (PGMCRNACRS)^{b}	0.0203	(0.0218)	−0.0063	(0.0547)	−0.036**	(0.0147)	−0.0651***	(0.0131)	−0.129***	(0.0252)
Predicted value of share of GM cotton acres (PGMCTNACRS)^{b}	−0.0041*	(0.0023)	−0.0012	(0.0034)	0.0017	(0.0026)	0.0049***	(0.0017)	0.0111***	(0.0027)
Predicted value of share of GM soybean acres (PGMSYBNACRS)^{b}	−0.0008	(0.0019)	0.0018	(0.0046)	0.0055***	(0.0013)	0.0077***	(0.0015)	0.0118***	(0.0028)
Government payments (GOVTPMT)	0.0238	(0.0479)	−0.0015	(0.0461)	−0.0125	(0.0208)	−0.019	(0.0188)	−0.0508	(0.0329)
Farming operations use computers (COMP)	0.0094	(0.0242)	0.0143	(0.0281)	0.0308	(0.0196)	0.0395*	(0.0213)	0.0443	(0.0352)
Farming operations use business plan (MGMT)	−0.0169	(0.0363)	0.0009	(0.0554)	−0.0056	(0.0607)	0.0065	(0.0248)	−0.0558	(0.0384)
Number of decision makers in farm (NUM_DECIS)	−0.0141	(0.0116)	−0.0061	(0.0152)	−0.0053	(0.0146)	−0.0008	(0.0097)	0.0187	(0.0187)
Operator's education (EDUC)	0.0011	(0.0046)	0.0022	(0.0072)	0.0011	(0.0081)	0.0045	(0.0034)	0.0079	(0.0058)
Operator works off farm (H_OFFOP)	0.0001	(0.0002)	−0.0001	(0.0004)	−0.0001	(0.0001)	−0.0001	(0.0001)	−0.0002	(0.0002)
Operator's spouse works off farm (H_OFFSP)	−0.0001	(0.0001)	−0.0001	(0.0002)	−0.0001	(0.0001)	−0.0002*	(0.0001)	−0.0002	(0.0002)
Farm size dummy (SMALL_2)	0.0202	(0.0545)	0.0321	(0.0664)	0.0418	(0.0859)	0.0517	(0.1012)	0.0361	(0.2252)
Farm size dummy (SMALL_3)	−0.0159	(0.0359)	0.0083	(0.0539)	−0.002	(0.028)	−0.005	(0.0399)	0.0095	(0.2075)
Farm size dummy (SMALL_4)	0.0016	(0.0304)	0.0171	(0.0458)	0.003	(0.0296)	−0.0032	(0.0385)	0.0033	(0.2068)
Farm size dummy (SMALL_5)	0.074	(0.0948)	0.0613	(0.13)	0.0493	(0.0576)	0.0549	(0.0458)	0.0495	(0.2142)
Sale more than $500,000 (LARGE)	0.1217	(0.1321)	0.0851	(0.1606)	0.0752	(0.0673)	0.0742	(0.0481)	0.0895	(0.2144)
Farm debt to farm assets ratio (ADARAT)	−1.0769	(2.9581)	−0.0924	(1.0468)	0.1145	(0.3602)	0.4016	(0.3632)	1.057*	(0.6268)
Year dummy for 2004 (Y04)	0.0287	(0.0317)	0.0002	(0.0333)	−0.0202	(0.021)	−0.0435**	(0.0188)	−0.0843***	(0.0285)
Year dummy for 2005 (Y05)	0.028	(0.0262)	0.0126	(0.0299)	0.0015	(0.023)	−0.0133	(0.0199)	−0.0098	(0.0299)
Pseudo R^2	0.0481		0.0116		0.0223		0.0523		0.1256	
Sample size					2,139					

Notes: Significace at: *10, **5, and ***1 percent; ^{a}ROA is defined as the ratio of net farm income to total farm assets; ^{b}the predicted value of share of GM corn acres (PGMCRNACRS), share of GM cotton acres (PGMCTNACRS), and share of GM soybean acres (PGMSYBNACRS) are obtained from an adoption-model (equation (2)); Heckman's technique indicated that there was no self-selection present in the model; further, the McFadden's pseudo-R^2 for the estimated models, indicate reasonable explanatory power; in the interest of brevity, we will only present results of the profitability model; however, results of the adoption model are available from the authors upon request; numbers in parentheses are standard errors

Although the size of the impact is smaller, the message is still the same. Profitable farms whether operated by "young" farmers or "beginning" farmers, realize that debt can be a cheaper source of funding than internal equity if the operator knows that they will have sufficient funds to repay their debt obligations.

While the results are similar for the effect of adoption of the three GM crops and farm debt to asset ratio (ADARAT) on ROA between the "young" farmer group and the "beginning" farmers group, differences do exist across the other explanatory variables. First, the development of a business plan (MGMT) no longer has a negative and significant impact upon ROA at the 0.9 quantile for "young" farmers as it did with "beginning" farmers. The sign on the coefficient however, is still negative. The same result is observed for the operator working off the farm (H_OFFOP), while the sign on the coefficients remain negative for the 0.8 and 0.9 quantiles but not statistical significant. This lack of significance is possibly because "young" farmers are likely to have better knowledge of maintaining farming operation that are handed over to them from the previous owners, and they are more likely to know the extent to which they can work off-farm without affecting the ROA. On the other hand, "beginning" farmers, who may lack farming experience or farming knowledge, may be inclined to secure a solid income stream by working off-farm even at the cost of efficiency of the farm operation. This could be true if beginning farmers are risk averse and if they have more off-farming experiences than young farm operator. The same pattern and results hold true when examining farm size (SMALL_5) and sales of more than $500,000 (LARGE). The significance for the coefficients no longer exists but the sign on the coefficient remains the same.

Two variables that were not significant in the "beginning" farmers group but are significant for the "young" farmer group both at the 0.8 quintile are the use of a computer in the farm operation (COMP) and if the operator's spouse works off-farm (H_OFFSP). For those "young" farmers in the 0.8 quantile use of a computer is expected to increase profitability by 3.95 percent. While the "beginning" farmers group contains farmers who are over 40, and may have little experience with computers, majorities of the "young" farmer group grew up with access to and have familiarity with computers. This result likely increases their ability to utilize computers effectively in their operation to increase profit (ROA). Again, the signs on the coefficients are the same across groups. The impact of a farm operator's spouse working off-farm (H_OFFSP) is a decrease in ROA by 0.02 percent. These findings suggest that as the profitability of the operation increases the spouse plays an important role in the management of the operation. This finding is consistent with Johnson and Morehart (2006) who argue that as farms increase in size and complexity that members of the farm management team, during the management process, gain specialized experience in a specific farm management tasks that can help improve financial performance. This probably true, especially for "young" farmers who likely cannot afford to hire outside help so the operator must rely on the spouse for assistance in running the operation. Similar to the result for COMP the signs on the coefficients for H_OFFSP across all quantiles are the same for both the "beginning" farmers and the "young" farmer groups.

Summary and conclusions

With renewed focus on helping YBFR make their operations financially viable, this study uses a quantile weighted regression to analyze the financial performance of YBFR who have adopted GM crops with data from the 2004-2006 ARMS.

The methodology employed in this study corrects for the simultaneity of technology adoption and farm financial performance. Results conform to a majority of our a priori expectations, as the profitability of "beginning" farmers is positively influenced by the scale of the farm operation, and the amount of farm debt. An interesting take away from the quantile analysis shows that the adoption of a management plan by "beginning" farmers leads to a lower ROA for the farm operation, which is likely the result of the homogenous nature of the crops and lack of ability of "beginning" farmers to differentiate their product. Off-farm employment by "beginning" farmers has a negative impact on the farm's financial performance (ROA), an indication that "beginning" farmers cannot generate a higher total net income for their farm household by combining on and off-farm work.

The results obtained in this research allow us to present some takeaways that may prove useful to policy-makers, extension educators, "beginning" farmers, and future researchers in this area. First, "beginning" farmers could likely improve the profitability of GM crop adoption by seeking to form cooperative business arrangements with established farmers who grow similar agricultural products. Typically, established farmers have larger operations and more farming specific human capital than "beginning" farmers. In addition, the results, we have obtained here show that increasing the number of decision makers and the scale of the operation will increase the profitability of GM crop adoption. Thus, "beginning" farmers will benefit from the scale and experience effects they obtain from collaborating with established farmers, while at the same time providing the cooperative business arrangement with a decision maker who is more willing to welcome technological change into the operation (age effect). Second, it may prove useful to develop extension programs that explore and promote the need for and benefits of business relationships (by means of collaboration agreements, strategic alliances, joint ventures, etc.) between "beginning" farmers and established farmers. These business arrangements between established farmers and YBFR could also be supported through agricultural policy. For example, US farm policy could provide tax incentives for forming these business arrangements.

Future research would also seek to quantify the learning curve of "beginning" farmers who have adopted GM crops, since the profitability from adoption should increase over time. This increase in profitability stems from improvement in the skills needed to grow GM corps and a reduction in uncertainty about the performance of the GM crops relative to non-GM crops (Baerenklau, 2005). Extension programs that train and educate "beginning" farmers on not only the best management practices of GM crops but also on the risks and benefits associated with the adoption of GM crops should accompany this research. These programs should shorten the learning curve associated with the adoption of GM crops.

Finally, the results of this research suggest that some differences exist between "beginning" farmers and just "young" famers, and that these differences need to be examined in greater depth. For example, are "young" farmers who grew up on a farm, then went away to college before coming back to run the family farm operation at all similar to someone who has worked for thirty years and then decided to farm? More importantly, do USA agricultural policies affect these groups the same way and do they require the same type of extension training.

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