The Impact of Labor Constraints on the Farm Performance

Florence Ivy M. Santos
Department of Agricultural and Applied Economics
University of Georgia, Athens, GA 30602-7509.
Email: fmsantos@uga.edu

Timothy A. Park
Department of Agricultural and Applied Economics
University of Georgia, Athens, GA 30602-7509.
Email: TPark@agecon.uga.edu

Cesar L. Escalante
Department of Agricultural and Applied Economics
University of Georgia, Athens, GA 30602-7509.
Email: cescalan@uga.edu

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INTRODUCTION

Organic farming, an economically and environmentally sustainable farming system, is a more labor-intensive operation compared to the conventional farming system that employs larger farm machineries and synthetic agrichemicals. The organic farms' characteristic limited use of synthetic chemical inputs requires them to implement alternative techniques for pest removal, soil additions and conservation that are usually done manually. Several studies have provided empirical evidence on the organic farms' greater demand for farm labor inputs than their conventional farm counterparts. Padel and Zerger (1994) analyzed German farms and found that the number of workers employed was 12% higher for organic farms, both on a per farm and hectare bases. Among U.S. farms, estimated labor requirements for a mix of livestock and crop farms in the Corn Belt were 19.8 and 17.8 hours per $1,000 of crop output for organic and conventional farms, respectively, on a whole-farm basis (Klepper, et al., 1977).

Crop choice is an important factor that determines the relative greater use of farm labor inputs among organic farms vis-à-vis conventional farms. Dubgaard (1994), for instance, found that organic farms in Denmark utilize twice as much labor inputs per hectare as conventional farms due to the larger share of more labor-intensive operations (vegetables and dairy production) in the organic farming systems he analyzed. He estimates a reduction in the difference from ½ to ⅓ if such structural differences are eliminated.

The high labor-dependence of organic farms can potentially make them more economically vulnerable under stricter immigration policies that affect an estimated 12 million unauthorized immigrants, 40% of whom are hired as farm workers (Seid, 2006).

These illegal workers are mostly "poorly paid and poorly treated" (Smith, 2005) usually hired at wages below prevailing market rates. Their displacement under the stricter immigration policies will expectedly create labor shortages, which can be remedied if farm labor wages are increased significantly to attract workers from other industries. On the other hand, the legalization of the immigration status of most of these workers under the Senate version of the Bill will enhance their bargaining position to demand for better wages at or above prevailing market rates, in addition to the usual fringe benefits (insurance, bonuses and others) and better working conditions they deserve.

A survey was conducted among organic, transitioning, and conventional farmers in Georgia, North Carolina, South Carolina, Alabama, and Mississippi to determine any differences in labor management strategies among these farming systems as they respond to expected changes in farm labor market conditions as a result of stricter immigration policies. A total of 523 potential survey participants were identified through online farm directories and from contacts with organic farming associations, commodity groups, and local USDA agencies. The mailed survey questionnaire was designed to gather information on the farms' labor requirements and how these requirements have been previously and are currently met by the respondents. The survey collected farm labor-related information on actual and expected decisions on the substitution of family with hired labor (or vice versa), employment of full-time versus part-time workers, seasonal versus year-round hiring of farm labor. Moreover, the farms were also asked to provide information on other business management strategies that either complement or supplement such labor management decisions in sustaining or enhance the farms' profitability and viability. These business strategy variables include changes in the production profile and allocations (or enterprise mix), farm size adjustments, and modifications of investment decisions (farm versus off-farm activities). Finally, the respondents' structural, demographic, and financial attributes were also collected and considered for their potential influence on labor management strategies.

This study utilizes the inputs of 72 respondents that provided complete, usable information. This dataset offers a good mix of enterprises that include vegetable, herb, nursery, floriculture, greenhouse, grains and pasture farm enterprises operating in the Southeastern states covered. This study will analyze the impact of hiring constraints and changes in farm labor market conditions (due to stricter immigration policies) on the technical efficiency of organic and conventional farms. Comparative farm performance and impact of different labor management practices employed by organic and conventional farms in the Southeast will be assessed using a production function approach.

The Model

This section provides a discussion of this study's analytical framework and a descriptive summary of the variables included in this study's empirical model.

Translog Production Function Model

The translog functional form was chosen for it's flexibility in estimating the elasticities as compared to the strong restrictions imposed by common production functions like the Cobb-Douglas and CES functional forms. The translog production function does not have an a priori restrictions on substitutability and in addition, its linearity allows for the use of OLS regression to estimate the parameters of the model.

$$\ln y = \alpha_0 + \sum_i \alpha_i \ln x_i + \frac{1}{2}\sum_i \sum_j \beta_{ij} \ln x_i \ln x_j + \sum_q \gamma_q \ln r_q + \frac{1}{2}\sum_i \sum_q \gamma_{iq} \ln x_i \ln r_q + u_i$$

where y_i represents the observed output measure for the ith farm, x_i is the set of farm inputs with farm and region specific measures denoted by r_i and $\beta_{ij} = \beta_{ji}$. The estimated parameters of the model are identified by α, β, and γ. The u_i are i.i.d. random variables.

The parameters of translog functional form can be estimated using ordinary least squares (OLS), maximum likelihood (ML), and nonlinear least squares (Coelli et al. 2005). This study used OLS in its estimation. The advantage of using OLS is that when the data obtained satisfied the Gauss-Markov assumptions[1], then the parameter estimated is the best linear unbiased estimate among linear estimators (Abdi 2003). In addition, when the Gauss-Markov conditions hold, OLS estimates are also maximum-likelihood estimates (Abdi 2003).

Descriptive Statistics

The dependent variable in the production function estimation is the logarithm of total gross income from farming in 2006 (*INCOME*). The sample used in this analysis has an overall mean gross farm income of $129,287. Of the three farming system categories, farms that are in transition from conventional to organic have the lowest mean gross income of $23,055 compared to organic farms ($44,609) and conventional farms ($229,632).

Labor and farmland inputs to production are represented in the model by LABORTOT and TACRE, respectively. LABORTOT is the total annual farm labor in

[1] The 5 assumptions are the following: (1) the data obtained constitute a random sample from a well-defined population; (2) the population model is linear; (3) the error has a zero expected value; (4) the independent variables are linearly independent; and (5) the error is normally distributed and uncorrelated with the independent variables (i.e. homoskedasticity assumption).

2006 calculated from man hours allotted on farm pre production, production, processing, harvesting, marketing and other farm work for all the enterprise categories. The mean LABORTOT in the sample is 4,638 man hours in one year (2006). This translates to a rate of 460 hours per acre per year. Among the farming system groups, organic farms have the highest mean LABORTOT/acre at 605 man hours per acre per year while in-transition and conventional farms registered rates of 405 and 352 man hours of labor per acre for the year 2006.

The sample's average farm size is 121 acres. However, disaggregating this into farm types we see that the typical organic and in transition farm sizes in the sample are about 11 acres and 15 acres respectively while the conventional farms in the sample has a mean farm size of 242 acres. A larger variability among conventional farms is noted as farm size ranges from 1 to 2000 acres for these farms. On the other hand, the size of organic farms did not exceed 51 acres while the sizes of farms-in-transition fall within a narrower range from 1.5 acres to 32 acres.

Following Tzouvelekas, Pantzios, and Fotopoulos (2001) that established a positive significant education effect on farm productivity, education is included in the model as a proxy for entrepreneurial skills. Sixty-three percent of the sample has at least attended some years in college; about 24% have some graduate work while the remaining 14% acquired a high school degree.

Our analysis also validates Edwards' contention (2006) that many farm employers prefer providing non-cash benefits to workers since the benefits can substitute parts of what otherwise would have been cash wages. Besides, such benefits are not subject to Social Security taxation. Furthermore, many employers offer additional benefits to encourage good job performance that will eventually translate to higher farm productivity (Edwards, 2008). Our survey data confirms these compensation arrangements as some farm employers in our sample provide non-cash benefits to their non-family workers, in addition to regular wages paid. Thirty-six percent (36%) of the respondent farms give additional benefits to their farm employees (BENETOT). About 46% of these additional in-kind benefits such as produce that the workers are allowed to take home. Free housing and free meals are also common additional benefits given to workers, both comprising 23% of additional benefits.

In dealing with labor shortages, ADSTRATG represents an ordered variable from 0 to 5 reflecting the number of adjustment strategies adopted by farmers in the event of a labor shortage. Only 18% of the farmers in the sample do not adopt any adjustment strategy while the majority implements one or a combination of the coping strategies discussed below.

Majority of the farmers (68%) in the sample adjust farm strategies and/or structure (ADJFARMPRAC). Specifically, when faced with labor shortage, farmers adjust through downsizing, changing their production plans to involve commodities that require less labor, investing in more machineries to reduce the need for more labor inputs and venturing into adopting other farming methods that do not rely much on labor. On the other hand, thirty nine percent (39%) of the farmers adjust the man hours they and/or other members of their own household spend working on the farm (ADJOWNLAB). These farmers either reduce their off-farm working time and work more in the farm and/or rely more on family members to devote more time on farm work, while some even consider quitting off-farm work to make up for labor supply shortages on the farm.

Twenty-six percent of farmers deal with shortages by adjusting wages or benefits offered to non-family labor (ADJWAGEBEN). They either increase the wage rate they offer and/or offer fringe benefits to attract some available non-family farm workers for hire. These strategies are not mutually exclusive so combinations of these strategies are adopted by farmers whenever they see fit.

Estimation Results

The output elasticities were obtained from the coefficient estimates of the translog model shown in Table 2. Both the output elasticities of acreage and labor were calculated by taking the derivative with respect to the logarithm of the each respective input measure, adding in the coefficient estimates of the linear and quadratic terms. These output elasticities measure the change in gross farm income due to a specified change in the use level of an input. The resulting output elasticities indicate that a one percent increase in labor used increases farm income by 0.35 percent. The acreage elasticity indicates that a one percent increase in acres of land used in farming increases farm income by 0.27 percent.

The sum of the output elasticities is the scale elasticity, which measures how output changes when the producer increases the use of both inputs. The estimated scale elasticity increases with the size of the farm, moving from a returns to scale measure of 0.62 for all farm to 0.79 for farms in the 75^{th} percentile of acreage size.

Providing additional benefits to workers is found to have a positive and statistically significant effect on farm income. This supports the argument that giving additional benefits encourages higher labor productivity, which in turn, increases the overall farm efficiency. The results for the education-related variable seem counter intuitive as farmers whose highest educational attainment is only at the high school level turned out to have significantly higher incomes. This result implies that there could be other factors, such as the length and quality of farming experience that could more effectively capture managerial ability than education.

The variable indicating the adoption of one or more adjustment strategies when dealing with labor shortage is found to be a positive and statistically significant predictor of farm income. Having the ability to adopt strategies that turns out to be effective in dealing with labor shortages suggests managerial capacity. In order to investigate this, we considered specific labor shortage adjustment strategies and categorized them into three general strategies: adjust own labor, adjust wages and benefits or workers, adjust farm practices (crops, machinery, etc). These are used to define four different adjustment strategy models that we analyzed here. A general model is first estimated and followed up by an estimation of three disaggregated models corresponding to each of the three categories of strategies earlier defined. (See Table 3).

Results of the four regression analyses suggest that while adopting a strategy significantly affects farm income, adjusting farm through either downsizing, changing commodities or adjusting the farms' machinery complement do not significantly influence income in the sample. This result suggests that while a combination of strategies works, adjusting solely production size or scope does not. It is likely that such individual adjustment strategies may have a lagged effect that are not easily realized in the short-run, but their effects could probably take effect only in the long run.

Adjusting family labor availability alone also does not significantly affect farm income. Increasing family labor inputs may not be enough to make up for the labor shortage. On the other hand, adjusting wage benefits of non-family labor is found to be positive and significant at the 10% level. The model suggests that wage benefits directly affect farm income, suggesting perhaps higher productivity among workers that are well-compensated. Furthermore, adjusting compensation in times of shortage may be the most effective strategy in retaining or attracting non-family labor, which then impacts labor supply and thus, farm income. Going back to the original model showing the positive correlation of farm income and the number of adjustment strategies adopted, we could surmise that adjusting wages and non-wage benefits, coupled with other strategies, translates to a higher farm income.

Summary statistics of the data show that farmers who already give additional benefits to their employees have statistically higher income. Adjusting wage benefits could mean taking steps that do not involve increasing wages but including non-wage benefits to attract and retain labor force.

Consequently, we examined whether the production function is the same between the group of farmers that adopt a certain adjustment strategy and those who do not. Using the Chow test, the pooled production function that essentially restricts the coefficients to be the same across the two groups is tested against the unrestricted model which allows for differences in the coefficients of the two groups.

The value of the F-statistic ($F_{9,54} = 8.98$) which gives a p-value of 0.00 leads us to reject the null hypothesis that there is no difference between the two groups. We propose that the ability to adapt certain strategies to deal with labor shortage suggests better managerial ability. Studies suggest that better managers should get a higher return on their investments (Ford and Shonkwiler, 1994; Tzouvelekas, Pantzios, and Fotopoulos , 2001; Lohr and Park, 2006).

Summary statistics of the two groups in Table 1 show that those that adopted an adjustment strategy for labor shortages have a significantly higher mean farm income of $150,781 compared to those without strategy whose mean farm income is only around $31,730.

The group with a positive adjustment strategy also devoted higher labor hours per acre per year on the average (470 man hours per acre per year) as compared to the group that do not have a strategy (414 man hours per acre per year).

Those that have adopted a strategy or combination of strategies own a significantly larger farmland with a mean of about 145 acres as compared to a mean of 11 acres for the zero strategy group. Even excluding extremely huge land area of above 1000 acres, mean land ownership is 92 acres for farms that adapt a strategy.

These are preliminary results that could be further explored by estimating and analyzing two separate production functions for these two groups, which will be the future direction of this study.

Summary and Conclusion

This study investigates the technical efficiency of a mix of conventional, transitioning and organic farms in light of changes in farm labor market conditions due to stricter immigration policies. The results of the analysis from the survey data showed that the number of adjustment strategies adopted is positively related to income. We also found productivity difference between the group of farmers which adopts at least one strategy and the group that has zero strategy and the summary statistics further showed that the former group has higher mean farm income. The ability to recognize effective adjustment strategies on times of unfavorable and changing market conditions suggests better management/entrepreneurial skills, which is an important determinant of farm efficiency.

The different production function models allowed for the evaluation of what strategy/ies are most likely to be the most effective when farm labor market conditions change. Among the adjustment strategies, adjusting wages and nonwage benefits have been determined to be the most effective strategies to cope with labor shortages. The results however suggest that adopting a combination of strategies is recommended. For example, while relying on own labor adjustment alone will not suffice in dealing with labor shortage, doing this in addition to adjusting the compensation package for nonfamily labor will off-set the increased farm production costs from raising wages for those nonfamily workers that the farm want to attract or retain. Also, adjusting compensation while at the same time adjusting farm practices could prove to be an effective strategy in order to retain and attract labor during much needed periods while the time lagged positive effects of adjusting farm practices will also be realized in the long run.

Providing additional benefits aside from regular wages has a significant positive impact on organic farm income. This implies that adjusting compensation does not have to translate to significant increase in wages. Furthermore, these additional benefits suggests better working condition which encourages good job performance that will eventually translate to higher farm productivity.

Table 1. Variable Descriptions and Summary Statistics (N = 72 farms)

Variable	Description	Summary Statistics[a]	Positive Strategy	Zero Strategy
INCOME	Total gross farm income in 2006, U.S. dollars (US$)	129,286.70	150,781	31,730.42
		(358,231.70)	(392,440.7)	(48,200.7)
LABORTOT	Total annual labor (in man hours)	4,637.78	2,232	5167.87
		(12,724.10)	(2,856.64)	(13961.37)
TACRE_LABORTOT	Total annual labor per acre (in man hours)	460.27	470.381	414.41
		(1051.07)	(1145.49)	(437.73)
TACRE	Acreage farmed in 2006	120.70	144.96	10.60
		(317.26)	(346.22)	(12.19)
HSCHL	Completed high school, 1 if yes	0.14	0.14	0.15
	Percent of total	13.89	13.56	15.38
COLLG	Attended at least some years in college, 1 if yes	.61	.64	
	Percent of total	62.50	64.41	
GRADDG	At least some graduate work, 1 if yes	0.23		0.31
	Percent of total	23.61		30.77
BENETOT	Farms providing cash or non-cash benefits to hired workers aside from the regular wages paid, percent of total	.36	0.39	0.23
	Percent of total	46.15	38.98	23.08
ADJOWNLAB	Adjust own or family labor supply, 1 if yes	.39		
	Percent of total	38.89		
ADJWAGEBEN	Adjust wages or benefits offered	0.26		
	Percent of total	26.39		
ADJFARMPRAC	Adjust farm practices: downsize, change commodities, adjust machinery	0.68		
	Percent of total	68.06		

[a] Numbers in parentheses are standard deviations.

Table 2. Production Function parameter estimates (N = 72 farms)

Parameter	Variable	Coefficients[b]
α_0	Constant	10.14281***
		(7.71)
α_1	ln(TACRE)	-.2208048
		(-0.57)
α_2	ln(LABORTOT)	-.4397474*
		(-1.79)
β_{11}	ln(TACRESQ)	.1561379*
		(1.80)
β_{22}	ln(LABORTOTSQ)	.1169283***
		(3.12)
β_{12}	ln(LABORTOT) **x** ln(TACRE)	.002793
		(0.08)
γ_1	BENETOT	.721824**
		(2.31)
γ_2	COLLG	-1.169149
		(-2.62)
γ_3	GRADDG	-1.162499
		(-2.30)
γ_4	ADJSTRATG	.1723135*
		(1.79)
R-squared		0.61

[b] Asymptotic t-values in parentheses with * denotes significance at α = 0.10 level, ** denotes significance at α = 0.05 level and *** denotes significance at α = 0.01 level.

Table 3. Different models with adjustment strategies (N = 72 farms)

Parameter	Variable	ALL[c]	Adjust farm practices[c]	Adjust own labor[c]	Adjust wage benefits[c]
α_0	Constant	10.40912***	9.940883***	9.863479***	10.42967***
		(7.62)	(7.44)	(7.30)	(7.77)
α_1	ln(TACRE)	-.2613551	-.126394	-.0799576	-.2564204
		(-0.65)	(-0.32)	(-0.20)	(-0.66)
α_2	ln(LABORTOT)	-.469015*	-.4146764	-.3786457	-.453307*
		(-1.85)	(-1.65)	(-1.50)	(-1.84)
β_{11}	ln(TACRESQ)	. 1511608*	.1511343*	.1485406	.1535294*
		(1.71)	(1.70)	(1.66)	(1.77)
β_{22}	ln(LABORTOTSQ)	.1142405***	.120479***	.1169953***	.1131368***
		(2.98)	(3.14)	(3.03)	(3.01)
β_{12}	ln(LABORTOT) **x** ln(TACRE)	.0091031	-.0078177	-.0110663	.0084744
		(0.26)	(-0.24)	(-0.33)	(0.25)
γ_1	BENETOT	.7392905**	.7053083	.7160096**	.7642596**
		(2.31)	(2.20)	(2.23)	(2.43)
γ_2	COLLG	-1.072016**	-1.067605**	-1.025409**	-1.081838**
		(-2.36)	(-2.37)	(-2.23)	(-2.45)
γ_3	GRADDG	-1.078768**	-1.096478**	-1.042897*	-1.084504
		(-2.08)	(-2.13)	(-1.98)	(-2.15)
γ_4	ADJFARMPRAC	.2331996	.2234816		
		(0.77)	(0.74)		
γ_5	ADJOWNLAB	-.1096728		-.0622688	
		(-0.38)		(-0.21)	
γ_6	ADJWAGEBEN	.5753354*			.5783241*
		(1.75)			(1.78)
R-squared		0.62	0.60	0.59	0.61

[c] Asymptotic t-values in parentheses with * denotes significance at α = 0.10 level, ** denotes significance at α = 0.05 level and *** denotes significance at α = 0.01 level.