ESO 2394

Factors Affecting Performance Measures of Northwestern Ohio Farms

E. Neal Blue and D. Lynn Forster

Research Question

Farming system practices (e.g. crop rotations and tillage systems) influence environmental parameters such as soil erosion and pesticide runoff. Changing in these practices to reduce environmental externalities may impact profit and efficiency. The main objective of this paper is to determine the effects of farming practices, firm capital structure, and operator characteristics on two firm performance measures, return on assets and overall efficiency.

Literature Summary

Several studies have focused on economic aspects of alternative farming systems. The use of an alternative system (no commercial fertilizer; no herbicides and moldboard plow; oat-alfalfa soybean-corn), in one study resulted in the highest average net income over costs, excluding management costs compared to conventional and ridge-till systems over a five year period. However some rotations may reduce net returns. In spite of reported positive attributes of alternative tillage systems, there may be some short term penalties associated with their adoption.

Study Description

Profit, as measured by return on assets, and overall technical efficiency are measured for a set of farms in the Lake Erie Basin in Ohio. Regressions analysis is performed to determine the effects of farming practices, farm capital structure, and operator characteristics on return on assets and overall efficiency.

Applied Questions

Do tillage practices and crop rotations influence firm level performance?

This study shows that tillage practices and crop rotations have no effects on farm profitability and efficiency. A typical farm's performance is most likely to be influenced by farm size and farm capital structure.

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Abstract:

Two performance measures, return on assets and overall efficiency, are calculated for a set of Ohio farms in the Lake Erie Basin in 1987, 1988, 1990 ,and 1992. These performance measures are analyzed to determine if they are affected by farming practices, capital structure, and farm operator characteristics. On average Ohio Farms in the Lake Erie Basin exhibit a 54 percent overall efficiency and a 5.25 percent return on assets for the four years studied. Farm size influences return on assets (ROA) and overall efficiency. Crop rotations and tillage practices have no statistical effects on ROA and overall efficiency.

Factors Affecting Performance Measures of Northwest Ohio Farms

The purpose of this study is to investigate factors affecting two measures of performance, relative overall efficiency and return on assets (ROA), for a representative sample of northwest Ohio farms located in the Lake Erie Basin. Factors hypothesized to be associated with differences in relative overall efficiency and ROA include farming practices, capital structure, and farm operator characteristics. Of particular interest are the effects of farming practices, such as conservation tillage and crop rotations, which are capable of reducing agricultural pollution in Lake Erie and its tributaries.

Review of Literature

Several studies have focused on economic aspects of alternative farming systems. Smolik and Dobbs (1991) investigated the economics of alternative farming systems in an experimental agronomic setting using enterprise budgets. They compared the use of an alternative system (no commercial fertilizer; no herbicides and moldboard plow; oat-alfalfa soybean-corn), a conventional system (moldboard plow, corn-soybean-spring wheat), and a ridge till system (corn-soybean-spring wheat). Five years of results indicated that the alternative system had the highest average net income over costs, excluding management costs. Foltz, Lee and Martin (1993), using simulation and linear programming techniques, found that introducing alfalfa into an eastern com belt rotation reduced net returns by 38 percent. They concluded that reducing com acreage by incorporating an alfalfa based rotation might be an environmentally sound policy; however, it would be costly to farmers.

Studies by Lockeretz et al. (1984) and Batte, Forster, and Hitzhusen (1993) compared organic and conventional farms in the U.S. Lockeretz et al. (1984) , using case studies, found the relative profitability for both the organic and conventional systems was about the same. Gross receipts from organic farms were lower than those from conventional farms; however, production expenses were also lower. Batte, Forster, and Hitzhusen (1993) using surveys of both organic farmers and conventional farms from the Ohio Farm Household Longitudinal Survey found that whole farm profits did not differ greatly between conventional farms and certified organic producers.

Numerous studies, as exemplified by Williams and Klemme (1988), have shown alternative tillage practices (conservation tillage, no-till, and ridge till) to be more profitable than conventional systems (moldboard plow and disk twice) under a wide range of operating environments . However, Featherstone et al. (1991) reported no statistically economic differences among tillage systems (conventional, ridge-till, and no-till) used on a sample of farms. One of the concerns of Featherstone et al. (1991) was that in spite of reported positive attributes of alternative tillage systems, there may be some short term penalties associated with their adoption.

Model and Data

Return on assets (ROA) and relative overall efficiency are the two measures of performance used to assess the economic effects of alternative farming practices, capital structure, and farm operator characteristics. Return on assets is an accounting based measure that reflects an economic return to assets deployed in the production process. It is calculated as:

1) ROA = (net farm income - charge for unpaid labor + interest on debt) / (farm assets)

The measure of overall efficiency is derived from an expenditure constrained profit optimization DEA model proposed by Fare, Grosskopf and Lee (1990). Overall efficiency is the ratio of actual profit to the short-run unconstrained profit derived from the profit optimization DEA model.[1] It is a measure of how much a firm's actual profit is falling short of a theoretically derived maximum profit because of production choices and expenditure constraints.

The set of Lake Erie Basin farms participating in the Ohio Farm Household Longitudinal Study (Stout, Forster, and Edgington, 1992) for 1987, 1988, 1990, and 1992 are included in the sample. The sample is restricted to farms having gross farm income larger than $40,000 in order to represent commercial farming and exclude rural residents with a peripheral interest in agriculture. Demographic, off-farm employment, financial, production, and marketing data were collected each year of the survey. These data are used in this analysis to compute overall efficiency and ROA measures for each farm in the sample in the years 1987, 1988, 1990, and 1992, and the number of farms in the sample total 98, 112, 127, and 113 in each of the respective years.

Implementation of DEA and ROA Analyses and Results

Revenues, variable, and fixed costs are used in the expenditure constrained profit DEA model. The revenues for the profit DEA model are corn, soybean, wheat, hay, beef, pork, dairy, other revenue, and government payments. Crop revenues come from both rented and owned land. Other revenue includes income received from custom work and land leased to other operators. Variable costs are: a) chemical costs, b) fertilizer plus seed costs, c) energy costs including fuel, storage, drying, and utilities, d) feed costs, e) labor costs including operator and hired labor, f) purchased livestock, and g) miscellaneous costs. Fixed costs are: a) a charge for capital which is defined as the interest costs on the farm's net worth plus the cash rent for land and buildings, b) machinery depreciation plus the use of custom hired machine expenses, and c) overhead expenses, which

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[1] For details on how overall efficiency is generated from the expenditure constrained profit optimization model see Fare, Grosskopf, and Lee.

include insurance, interest and finance charges, repairs and maintenance, taxes, and conservation expenses. The interest rate used to compute the cost of equity capital is the cash rental rate as a percent of land value, as reported in Acker and Lee. These values are 5.7%, 5.5%, 5.5%, and 5.5% in 1987, 1988, 1990, and 1992, respectively.

For all years, variable and fixed costs comprise approximately 62 and 38 percent of total costs, respectively (Table 1). The three largest variable costs on average are labor, feed, and fertilizer and seed. The mean actual profit for farms in this sample ranges from a low of $2,706 (1992) to a high of $18,922 (1988).

As previously discussed, relative overall efficiency is calculated as the ratio of actual profit to the programming generated short-run unconstrained profit. Because some farms within each year achieve a negative profit, the actual and short-run unconstrained profit values in a given year are shifted upward by the most negative profit within that year.

The overall efficiency scores are bounded between zero and 100%. Overall efficiency ranges from 33% (1988) to 70% (1992) and averages 54% for the four years (Table 2). The relatively low overall efficiencies exhibited by a majority of farms is indicative of the actual profit being substantially lower than the theoretically derived short-run unconstrained profit. That is, given the actual variable and fixed input expenditures for a particular farm, it should be able to achieve the theoretically defined short-run unconstrained profit. This loss in profit and hence lowered overall efficiency may be the result of misallocation of resources or information asymmetry (Tauer, 1993). It also may be due to factors outside of the farm operators control, e.g., adverse weather or volatile prices. The lowest overall efficiency occurs in 1988 when many farms experienced a drought which reduced yields and revenue. Mean overall efficiency reported in Fare, Grosskopf and Lee (1990) for a set of California rice farms is about 60%.

Mean annual average return on assets for the farms in this study ranges from 2.98% (1992) to 7.26% (1988) and averages 5.25% for the four years. Enormous variability in return on assets occurs in each year (Table 2). In each year, a sizable proportion of farms in the sample have negative returns on asset, but also a sizable proportion have rates of return on assets exceeding 15%.

The two measures of performance, overall efficiency and rate of return on assets, are conceptually different; however, they are correlated in this sample. Pearson correlation coefficients for these two measures of performance are 0.51, 0.53, 0.32, and 0.41 for the four years.

Regression of Return on Assets and Efficiency Scores

A major assumption of DEA is that qualities or factors not accounted for by the model are homogeneous. This assumption is hard to justify. As a result, the DEA efficiency measures may be influenced (or contaminated) by nonhomogeneous factors. To assess this possibility, overall efficiency derived in the previous section is used as dependent variable in regression models which includes operator and farm characteristics. Similar types of analyses have been performed to assess the factors associated with nursing home efficiency (Fizel and Nunnikhoven, 1993), educational efficiency (Lovell, Walters, and Wood, 1989), New York dairy farms (Tauer, 1993), and West Bengal farms (Ray, 1985). In addition, the same regression variables are used in regressions where return on assets is the dependent variable. The regressions are performed for each year separately.

In this analysis, gross sales and its squared term is used as a measure of farm size. Overall efficiency and ROA are expected to increase as farm size gets larger under the assumption that larger farm operations are better able to obtain equity and debt capital; thus, the possibility of facing a binding expenditure constraint is reduced. In addition, the increase in overall efficiency as farm size gets larger would reflect technological and pecuniary economies of scale.

Personal characteristics such as motivation and willingness to accept risk change over the operator's lifetime and may contribute to a life cycle of growth and decline of the farm business (Nelson, 1968). On the other hand, older farm operators may have acquired skills to more efficiently allocate resources to end uses. Thus it is expected that older operators will operate farms that have a higher return on assets and overall efficiency. Age is defined as the age of the primary decision maker in the household.

The number of years of education possessed by the farm operator may positively influence ROA and overall efficiency because more highly educated producers may be better at evaluating new information and quicker to adopt innovations (Asplund et al., 1989; Rogers et al., 1988). The adoption of innovations may lead to increased actual efficiency because of improved resource allocation. Tauer (1993) found no effect of education on dairy farm efficiency. However, in other studies (Belbase and Grabowski, 1985; Kalirajan and Shand, 1986) education is shown to positively impact technical efficiency. Education enters the regression model as three dummy variables representing four education classes. The dummy variables used in the regression are Education (< 12 years), Education (>12 & <16 years), Education (=>16 years). Education (=12 years) is left out to prevent model singularity.

Growth in gross farm output and profit is often accompanied by increased financial leverage. This may be due to technical change (Shepard and Collins, 1982) or personal characteristics such as motivation, ambition, and willingness to accept risk (Upton and Haworth, 1987). Upton and Haworth (1987) found that farm size and growth are positively associated with an increased propensity to invest. Bravo-Ureta and Pinheiro (1993) demonstrate that credit use has a positive impact on technical efficiency. The use of debt may ameliorate the binding expenditure constraint faced by some firms and thus will lead to increased overall efficiency and ROA. In this study debt load is measured as the debt to asset ratio.

Information collection and use are important managerial activities. As a farm becomes larger, more management expertise is required. Often this information comes from outside sources via consultants or through the use of computers. Farmers who seek greater amounts of information from numerous sources are more likely to adopt innovations (Feder and Slade, 1984; Asplund et al., 1989). Bravo-Ureta and Pinheiro's (1993) review of efficiency in developing country agriculture shows that information use positively impacts efficiency. Tauer (1993) shows that the use of a more elaborate accounting system improves dairy farm efficiency. In this study, a 0-1 dummy variable measures information use with I indicating that the farm operator used computers, consultants, or extension agents, and 0 indicating that these information sources were not used .

Rotations and tillage practices are used as explanatory variables to examine the effects of various farming systems on actual and financial efficiency. The array of rotations and tillage practices used on farms in the sample are categorized into four rotations and four tillage systems. These are shown in Table 3.

In the regression models, Rotations 2, and 3, and tillage patterns 2, 3, and 4 are dummy variables included in the regression. Rotation 1 and Tillage 1 are left out of the regressions to prevent model singularity. In 1992, rotation is modeled as several variables detailing the percentage of tillable acres in no-till, moldboard plow, disk only, ridge-till, other tillage, and chisel plow. The percentage of land that is chisel plowed is left out of the 1992 regression to prevent model singularity.

Regression Results

Mean and standard deviation statistics on the variables used in the ROA and overall efficiency regressions are presented in Table 4. The ROA and overall efficiency regressions for each year are presented in Tables 5 and 6, respectively.

Return on Asset Regression

Gross sales and age are the only variables that consistently influence ROA year to year. Education, information use, rotations, and tillage systems had effects on ROA but only in a particular year (Table 5).

In three out of the four years, larger farms have statistically higher return on assets, as expected. In addition, the squared term of gross sales is also significant for all years. In 1987 and 1990 the squared term is negative indicating that ROA increases at a decreasing rate; in 1990 the squared term is positive, implying that ROA increases at an increasing rate..

Older age has negative impact on ROA in 1987,1988, and 1990. In 1992 older operators have a higher ROA. Older farmers having a lower ROA is a counterintuitive result. This result suggests that in general younger farmers achieve a higher ROA, possibly because of their lower degree of risk aversion.

Overall Efficiency Regression

Gross sales and capital structure are the only variables that have consistent effects on overall efficiency. Other variables such as age, education, rotation, and tillage are only significant for a particular year (Table 6).

Larger farms have a higher or lower overall efficiency depending on the year investigated. In 1987 and 1992 larger farms have a higher overall efficiency. However, in 1990 smaller farms have a higher overall efficiency.. The 1990 regression shows that the squared term for gross sales is positive indicating that as farm size increases, overall efficiency decreases slightly, reaches a minimum for gross sales of $540,000, and then increases for larger farms. Byrnes et al. (1987) reported in their study that larger Illinois crop farms have higher technical efficiency but slightly lower scale efficiency.

The strong positive relationship of debt use (DEBT/ASSET) with overall efficiency reflects that farms that use more debt have higher overall efficiency. Again as suggested earlier, this result suggests that the use of debt ameliorates the effect of a binding expenditure constraint and enhances overall efficiency.

Implications

On average, Ohio farms in the Lake Erie Basin exhibit a 54% percent overall efficiency and 5.25% return on assets for these four years. Their relatively low overall efficiency implies that given their resource base, most northwest Ohio farms are capable of improving profits by resource reallocation. Generalized least squares regression analyses are unable to document a statistically significant relationship between performance measures and crop rotations or tillage systems. These findings imply that those Lake Erie Basin farmers adopting crop rotations and conservation tillage practices have done so without sacrificing profits or efficiency.

Farm size positively or negatively affects ROA and overall efficiency depending on the year. In years when low output prices or drought resulted in financial losses for many farmers, large farms had little, if any, competitive advantage. Farms having higher debt/asset ratios have higher overall efficiency, which implies that farmers are successfully using debt to alleviate financial constraints. However, the use of debt had no effect on return on assets.

These results imply that for the majority of Ohio farms profits are falling short of their potential due to misallocation of inputs, e.g., too many or the wrong enterprises; inappropriate fertilizer application, seeding rates, or feed mix; animal health or pest control problems; inferior animal genetics or breeding practices; and excessive equipment costs. However, factors outside the operator's control, e.g., weather and volatile output prices, also may be influencing these performance measures.

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Table 1. Summary Statistics of Variable Costs, Fixed Costs and Revenues Used in the Nonparametric Expenditure Constrained Profit Optimization, Northwest Ohio Farms

Variable Costs	1987		1988		1990		1992	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Chemicals	6790	6739	9327	10124	8006	7376	11958	12040
Fertilizer & Seed	16067	12792	19362	16062	20605	23113	25862	23663
Energy	7969	4868	8278	5135	9563	8177	11254	9386
Feed	17845	25685	20118	29145	15860	31512	12479	34691
Labor	18221	12283	17217	10760	19367	13590	26200	22910
Purchased Livestock	15748	59708	12107	41118	9479	55971	7781	25925
Miscellaneous	3862	6999	3919	9130	3586	5575	1985	4004
Total Variable Cost	86502	83512	90328	74766	86466	92506	97519	77537
Fixed Costs								
Capital	26005	23967	23838	17798	26876	27511	30279	26816
Machinery	18461	19042	14790	15695	14601	14082	14740	16930
Overhead	12539	11901	12848	12650	12283	8856	16257	13850
Fixed Costs	57004	45954	51477	32753	53760	40607	61276	48295
Total Costs (Fixed + Variable)	143507	111201	141805	93587	140226	114589	158795	114860
Revenues								
Corn	19366	23387	19392	31691	27681	48117	41820	47583
Soybeans	27919	23656	28866	29422	35236	42751	46549	46104
Wheat	4787	5082	10004	10852	11241	14883	11509	13021
Hay	633	4345	996	5204	313	1794	401	1824
Beef	14990	65696	26137	86735	11953	77836	11746	46200
Pork	23898	56392	25386	67115	28450	84355	23660	81886
Dairy	28335	75793	24964	56982	26608	99153	14940	52914
Other Revenue + Government Payments	26908	47782	24983	34029	10024	19922	10876	15086
Total Revenue	146835	118842	160727	124816	151505	189185	161501	136720

Table 2. Distribution of Overall Efficiency and Return on Assets, Northwest Ohio Farms

	1987	1988	1990	1992
Overall Efficiency	percent	percent	percent	percent
0-9 %	2.0	8.0	0.0	0.9
10-19 %	0.0	31.2	0.0	0.0
20-29 %	1.0	23.2	5.5	0.0
30-39 %	10.2	14.3	28.3	0.9
40-49 %	20.4	5.4	23.6	3.5
50-59 %	28.6	3.6	11.0	12.4
60-69 %	14.3	2.7	9.4	43.4
70-79 %	4.1	0.0	3.9	15.9
80-89 %	4.1	1.8	5.5	8.0
90-99 %	4.1	0.0	3.1	8.0
=100 %	11.2	9.8	9.4	7.1
Mean (%)	60.0	33.0	54.0	70.0
Standard Deviation (%)	21.0	27.0	22.0	16.0

	1987	1988	1990	1992
Return on Assets	percent	percent	percent	percent
ROA < -10%	5.1	5.4	8.7	12.4
-10% <=ROA <-5%	5.1	7.1	9.4	15.0
-5% <=ROA < 0%	17.3	22.3	21.3	21.2
0% <=ROA < 5%	24.5	20.5	27.6	19.5
5% <=ROA < 10%	26.5	13.4	18.1	8.0
10% <=ROA < 15%	8.2	15.2	2.4	9.7
ROA >= 15%	13.3	16.1	12.6	14.2
Mean (%)	5.9	7.3	4.8	3.0
Standard Deviation (%)	20.3	21.8	23.1	26.4

Table 3. Crop Rotations and Tillage Practices Evaluated Used by Ohio Farms in the Lake Erie Basin.

Rotation	Variable Description	Example
Rotation 1 (Cont. Row Crop)	Continuous row crop	Continuous corn, corn-soybean, etc.
Rotation2 (R.crop/small grain)	R-R-R-Sg	Corn-corn-soybean-wheat
	R-R-Sg	corn-soybean-wheat
Rotation 3 (R.crop/small gr./ pasture)	R-R-R-Sg-M	Corn-corn-soybean-wheat-meadow
	R-R-Sg-M	corn-soybean-wheat-meadow
	R-R-Sg-M-M	corn-soybean-wheat-meadow-meadow
	R-Sg-M-M	soybean-wheat-meadow-meadow
Tillage 1 (Conventional till)	P-S-S-Plant	plow, disk, disk, plant
Tillage 2 (Chisel plow)	C-S-S-Plant	Chisel, disk, disk, plant
	C-S-Plant	Chisel, field cultivate, plant
Tillage 3 (Minimum Till)	S-S-Plant	disk, field cultivate, plant
	S-Plant disk,	
Tillage 4 (No till)		No-till plant

Table 4. Summary Statistics for the Variables Used in the Post DEA and Return on Asset Regressions, Northwest Ohio Farms

Variable	1987		1988		1990		1992	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Gross	151964	122648	167510	124500	159039	189012	184126	168733
Age	47.35	13.09	46.35	11.03	47.36	12.14	49.64	11.30
Education (< 12 years)	0.06	0.24	0.04	0.19	0.04	0.20	0.05	0.23
Education (> 12 & < 16)	0.24	0.43	0.21	0.41	0.32	0.47	0.26	0.44
Education (= > 16)	0.01	0.10	0.03	0.16	0.03	0.18	0.02	0.13
Education (= 12)	0.68	0.47	0.72	0.45	0.61	0.49	0.67	0.47
Debt to Asset Ratio	0.23	0.24	0.24	0.24	0.22	0.21	0.20	0.20
Information Use	0.47	0.50	0.46	0.50	0.36	0.48	n.a.	n.a.
Rotation 1	0.15	0.36	0.06	0.24	0.13	0.33	0.12	0.33
Rotation 2	0.62	0.49	0.65	0.48	0.68	0.47	0.67	0.47
Rotation 3	0.22	0.42	0.29	0.45	0.20	0.40	0.19	0.40
Tillage 1	0.41	0.49	0.61	0.49	0.46	0.50	n.a.	n.a.
Tillage 2	0.24	0.43	0.16	0.37	0.17	0.38	n.a.	n.a.
Tillage 3	0.15	0.36	0.14	0.35	0.12	0.32	n.a.	n.a.
Tillage 4	0.19	0.40	0.09	0.29	0.25	0.44	n.a.	n.a.
% in No-till							0.26	0.36
% in Moldboard							0.18	0.28
% in Chisel Plow							0.21	0.30
% in Disk							0.14	0.22
% in Ridge-till							0.15	0.34
% in Other tillage							0.07	0.19
Tilled Acres							664	514

Table 5. Least Squares Estimates of Selected Factors on Return on Assets, Northwest Ohio Farms

Variable		1987		1988		1990		1992
Intercept		-0.0243	**	0.2920		-0.0357	***	-0.5139
Gross	***	0.0000021		-4.32e-07	***	0.0000013	***	0.0000014
$Gross^2$	***	-3.11e-12	***	2.121e-12	***	-6.64e-13	***	1.32e-12
Age	*	-0.0032	***	-0.0052	*	-0.0029	**	0.0049
Education (<12 years)		0.1289		0.1034		0.0420		-0.0405
Education (>12 &<16)		-0.0450		0.0012		-0.0340		0.0388
Education (=>16)		0.0620		0.0099		-0.0113		-0.0934
Debt to Asset Ratio		-0.1189		-0.0807		0.0181		-0.0654
Information Use	**	-0.1225		-0.0199		-0.0208		n.a.
Rotation2	*	0.1124		0.0147		0.0674		0.1056
Rotation3		0.0557		0.0212	*	0.1198		-0.0029
Tillage2		0.0860		0.0275		0.0193		n.a.
Tillage3		0.0319		0.0290		-0.0372		n.a.
Tillage4		0.0448		0.0283		-0.0070		n.a.
Percent land in no-till		n.a.		n.a.		n.a.		0.0551
Percent land in moldboard plow		n.a.		n.a.		n.a.	*	0.1896
Percent land in disk only		n.a.		n.a.		n.a.		0.0257
Percent land in ridge-till		n.a.		n.a.		n.a.		0.1203
Percent land in other tillage		n.a.		n.a.		n.a.		-0.2029
R^2		0.2443		0.3285		0.2593		0.2354
Model F Test		2.089		3.687		3.042		2.155
Sample n=		98		112		127		113

*, **, *** denote probability of significance less than 0.1, 0.05, and 0.01, respectively.
n.a. - variable not used in this regression.

Table 6. Least Squares Estimates of Selected Factors on Overall Efficiency, Northwest Ohio Farms

Variable		1987		1988		1990		1992
Intercept	***	0.4352	***	0.6125	***	0.7347	***	0.5252
Gross	***	0.000002075		-0.00000078	**	-0.000000608	***	0.000000758
$Gross^2$	***	-2.5883e-12	**	2.00720e-12	***	5.641065e-13	*	-4.71602e-13
Age		-0.0018	***	-0.0082		-0.0026		-0.0002
Education (<12 years)		0.0739		0.1369		-0.0165		-0.0018
Education (>12 &<16)		-0.0225		-0.0326		-0.0168	**	0.0742
Education (=>16)		0.1326		-0.0957		-0.1370		-0.0524
Debt to Asset Ratio	**	0.2119	***	0.4681	**	0.1913	***	0.2544
Information Use	**	-0.1040		-0.0166		-0.0506		n.a.
Rotation2		0.0480		0.0540		-0.0178		0.0651
Rotation3		0.0289		0.0362		-0.0811	*	0.0373
Tillage2		0.0630		0.0043		0.0727		n.a.
Tillage3		-0.0638		-0.0294		-0.0607		n.a.
Tillage4		-0.0543		0.0407		0.0170		n.a.
Percent land in no-till		n.a.		n.a.		n.a.		-0.0679
Percent land in moldboard plow		n.a.		n.a.		n.a.		-0.0244
Percent land in disk only		n.a.		n.a.		n.a.	**	-0.1434
Percent land in ridge-till		n.a.		n.a.		n.a.		-0.0511
Percent land in other tillage		n.a.		n.a.		n.a.		0.0039
R^2		0.4151		0.3872		0.2045		0.4941
Model F Test		4.585		4.764		2.234		6.837
Sample n=		98		112		127		113

*, **, *** denote probability of significance less than 0.1, 0.05, and 0.01, respectively.
n.a. - variable not used in this regression.