Agricultural Economics Miscellaneous Report No. 128

April 1990

Simultaneity of Farm Financial Management Decisions in North Dakota

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Acknowledgments

This report represents the culmination of a research project involving numerous organizations and individuals. Our appreciation is extended to Dr. Larry Helt and the Farm Business Management program for graciously providing record data from their organization. A special thanks goes to each of the 500 members who belong to that organization. Finally, we would like to thank Roger Johnson, David Watt, and Larry Leistritz for valuable comments throughout this project and Shelly Swandal who did an excellent job of typing this document.

This report was prepared from a study conducted as part of North Dakota Station project ND01380, Financing Agriculture in a Changing Environment: Macro, Market, Policy, and Management Issues.

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Highlights

This study quantifies the simultaneity that exists among key financial management decisions on North Dakota farms and ranches. An eight-equation pooled cross-sectional, time-series econometric model and record data from 80 farms over a six-year period were used to ascertain the complexity of the farm financial management decision process and improve economists' abilities to recommend optimal policies.

Results of the study reveal substantial simultaneity among farm financial variables. Levels of farm income, off-farm income, capital, indebtedness, and investment are all mutually dependent on one another. In addition to primary effects, strong secondary effects were also discovered. Previous research has determined optimal values of these variables on an independent basis.

The study emphasizes the need for strong financial management skills on the part of farmers. The degree of simultaneity among key decisions in the management process illustrates the complexity of farm financial management. Farmers must have complete records and sufficient education in order to make informed decisions.

Simultaneity of Farm Financial Management Decisions in North Dakota

Gary W. Rourke and Cole R. Gustafson*

The previous decade was a stressful period for North Dakota farmers. The financial crisis in agriculture was the deepest and most widespread since the 1930s (Barry). One of the primary factors contributing to the crisis was the Federal Reserve Board's decision to tighten monetary policy in 1979 (Melton). Before then, farmers and lenders had liberal attitudes toward credit use. During the relatively stable 1960s and early 1970s, farmers' use of financial leverage for purposes of growth had largely been successful. Many North Dakota farmers expanded their business with debt capital in the latter 1970s. But when interest rates rose, these farmers began to experience severe cashflow problems as greater portions of residual income were allocated to debt service.

Two secondary effects of tight monetary policy compounded farmers' problems. First, reduced levels of inflation lowered the collateral value of farm assets. Second, the exchange value of the dollar rose and reduced foreign demand for U.S. farm products. Lower commodity prices and declining asset values decreased farmers' debt servicing capabilities even more.

In response to these sources of stress, farmers' interest in financial management has intensified. Financial management presents farm managers with numerous choices concerning firm size, enterprise mix, investment, debt usage, and off-farm employment. Financial management relates to all areas of farming including production, finance, and marketing.

This study develops a database to determine the simultaneity among key variables involved in the financial management of the farm business. Appraising the financial management practices of farmers is difficult because of the simultaneity among assets, investment, income, and debt variables. Past research efforts have identified optimal levels for each of these variables independently.

This study, however, quantifies relationships among these variables in a joint manner. For example, the study investigates the impact of alternative investment levels on farm profitability and, in turn, how that profitability affects a farm operator's investment opportunities. The remaining sections of this report discuss optimal financial management,

Optimal Financial Management

Optimal financial management occurs when farmers operate at the most efficient size and balance the usage of debt and equity in their firms so as to maximize profits and maintain a viable operation. Selecting the most efficient size of operation involves the concept of economies of size.

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Dalsted, Goodman, and Schneeberger studied economies of size on North Dakota small grain and livestock farms. All three studies discovered significant cost-per-unit declines on one-man farms as farm size increased. Cost increases per unit could not be detected on even the largest of farm sizes.

Optimal management of a firm's capital structure has been investigated by Barry, Collins, and Larson. An optimal capital structure is the combination of debt and internal equity capital that minimizes the average cost of investment financing. Increased use of debt can enhance returns to equity, but greater financial leverage also endangers the chances of firm survival, because net income levels vary while interest payments are a fixed obligation. These studies identified optimal capital structures for firms with differing business and financial characteristics. Following this theory, firms with similar business organizations would be expected to have identical proportions of debt and equity capital.

In North Dakota, farm businesses have an average debt-to-asset ratio of 39 percent (Gustafson, Nielsen and Morehart). However, considerable diversity exists among individual farm situations. About 18 percent of farm operators have no debt, 50 percent have debt-to-asset ratios between .01 and 40 percent, 23 percent have debt-to-asset ratios between .41 and .70 percent, and 9 percent have debt-to-asset ratios exceeding .70. Similar variation in other financial variables exists as well.

This level of variation in farm capital structures is surprising given the competitive nature of the industry. Either the optimum position is nonexistent, misspecified, or farmers have difficulty obtaining it. Additionally, large nonfarm firms obtain capital by issuing either debt or equity capital in national markets. Individual farmers do not have access to these markets. The limited availability of both retained earnings and debt capital can make it difficult for a small farm to obtain an optimal capital position. A final reason may be that farms operate with different resource endowments. The quantity and quality of production factors vary considerably by farm. For example, farmers living in geographic regions which afford off-farm work have an opportunity to supplement farm sources of income. This additional income may affect their decision processes.

Researchers in agricultural economics must understand the simultaneity associated with key financial variables if they are to recommend optimal policies of farm financial management to farmers. Without a complete understanding of the farm financial management process, optimal management recommendations may be biased or inappropriate.

Empirical Model

The empirical model to be tested in this study consists of the following seven equations:

Equation 1:

$$\begin{aligned} \text{L1 (Net Cash Operating Income)} &= \text{A1 (Intercept)} \\ &+ \text{A2 (Total Farm Receipts)} \\ &+ \text{A3 (Total Farm Expense)} \\ &+ \text{A4 (Total Capital Purchases)} \\ &+ e_t \end{aligned}$$

Equation 2:

$$\begin{aligned} \text{G27 (Total Farm Receipts)} &= \text{B1 (Intercept)} \\ &+ \text{B2 (Total Assets)} \\ &+ \text{B3 (Nonfarm Income)} \\ &+ \text{B4 (Family Living Expense)} \\ &+ e_t \end{aligned}$$

Equation 3:

$$\begin{aligned} \text{L4 (Nonfarm Income)} &= \text{C1 (Intercept)} \\ &+ \text{C2 (Net Farm Income)} \\ &+ \text{C4 (Total Capital Purchases)} \\ &+ e_t \end{aligned}$$

Equation 4:

$$\begin{aligned} \text{F13 (Total Liabilities)} &= \text{D1 (Intercept)} \\ &+ \text{D2 (Total Assets)} \\ &+ \text{D3 (Net Farm Income)} \\ &+ e_t \end{aligned}$$

Equation 5:

$$\begin{aligned} \text{F22 (Total Assets)} &= \text{H1 (Intercept)} \\ &+ \text{H2 (Net Farm Income)} \\ &+ \text{H3 (Nonfarm Income)} \\ &+ e_t \end{aligned}$$

Equation 6:

$$\begin{aligned} \text{L6 (Total Capital Purchases)} &= \text{M1 (Intercept)} \\ &+ \text{M2 (Nonfarm Income)} \\ &+ \text{M3 (Total Farm Expense)} \\ &+ e_t \end{aligned}$$

Equation 7:

$$\begin{aligned} \text{EXP (Total Cash Farm Operating Income Less Interest)} &= \text{N1 (Intercept)} \\ &+ \text{N2 (Total Assets)} \\ &+ \text{N3 (Nonfarm Income)} \\ &+ e_t \end{aligned}$$

A direct relationship is expected between net cash income and gross farm receipts. As the level of gross farm receipts increases, the level of net cash income would be expected to increase. Total farm expense is expected to have an inverse relationship with net farm income. As the level of farm expense increases, the level of net farm income will decrease. An inverse relationship is also expected with total capital purchases. As funds are used to purchase capital items, residual net farm income is depleted.

Gross farm receipts are expected to have a direct relationship with the level of assets on the farm. As the asset level (which would consist of land, machinery, livestock, and buildings) increases, the level of gross farm receipts will tend to increase.

An inverse relationship is hypothesized between nonfarm income and net farm income. As farm size increases, labor requirements increase as well. If time constraints exist, the farm family must choose between working on the farm or off.

Nonfarm income is expected to have a direct relationship with family living expenses and capital purchases. Greater levels of nonfarm income are hypothesized to lead to greater levels of family living expense and capital purchases.

Total farm debt is expected to have a direct association with farm asset levels because most asset purchases entail the use of debt capital. Higher levels of net farm income often lead to debt repayment.

A direct association is assumed between total farm assets and net farm income. Higher net farm income permits the acquisition of more farm assets. Likewise, increased nonfarm income is assumed to increase the farm's ability to purchase.

Capital purchases are expected to be directly associated with nonfarm income. As nonfarm income increases, it is assumed that some of this income could be used to purchase more capital items for the farm. A direct relationship between the level of capital purchases and total farm receipts is also hypothesized. Again, as the level of total farm receipts increases, the level of capital purchases would also be assumed to increase. Capital purchases are likely to be negatively related to total farm expenses. As total farm expense increases, less residual income is available for capital purchases.

Data Collection

Data to test the relationships hypothesized above were obtained from the North Dakota Vocational Agricultural Farm Business Management Program (FBM). This program was established in 1971. Currently, 469 farmers participate (Helt 1986). There are several advantages of using FBM data in this study. First, time series records from 1981-86 are available for analysis. This lengthy time series facilitates intertemporal analyses and represents conditions over several different periods of economic prosperity. A second advantage is that all of the data are reviewed by vocational ag instructors to insure accuracy. Third, considerable detail exists in the financial records -- more data than farmers typically maintain on an individual basis. Finally, standardized procedures are used in compiling the data.

There are two important limitations of FBM data. First, variable selection is somewhat limited due to the standardized accounting procedures involved. Second, farmers participating in the program were not obtained by random sample. Gustafson, Nielsen, and Morehart find that FBM members possess several unique characteristics when compared with average farmers in North Dakota. Without an adjustment, these differences make it difficult to extrapolate the findings of this study to all farmers in the state.

In order to insure homogeneity, the following criteria are used to select sample observations: 1) a farmer must have participated for all six years 1981-86, 2) the financial records of a farm must be complete, and 3) the size of the farm must have been between 160 and 3,500 acres.

A total of 80 farms met these above criteria. Rourke describes the farms' geographic locations, production organizations, sources of farm and nonfarm income, and financial characteristics in considerable detail.

These data are unique in that individual observations are available over a span of time. The process of combining cross-sectional and time-series data is referred to as pooling. Pooling of data can mitigate problems of multicollinearity and identification and can yield parameter estimates that are more efficient (Koutsoyiannis). This study utilizes the covariance method of estimating regression parameter coefficients (Pindyck and Rubinfeld). Dummy variables are added to the model to permit changing intercepts over the estimation period.

Model Results

Table 1 presents the empirical results of estimating the simultaneous equations. The model consists of seven equations with seven endogenous variables and twenty-two exogenous variables. Each equation is over-identified. The equations were estimated with the Statistical Analysis System (SAS) procedure, Proc Sysnlin. The Student's t-statistic is used to test the significance of each variable at $p = .05$. The following sections discuss the results of each equation and illustrate the simultaneous effects.

Equation 1 explains the variation in net cash operating income across the farms in the study's sample. Independent variables in the first equation consist of the intercept, total farm receipts, farm expense, and total capital purchases. The dummy variables representing the six years of data available were insignificant. Further, these variables contributed to a problem of multicollinearity. Thus, the dummy variables were dropped from all equations. The R^2 value for this equation is .5946, indicating that approximately 59 percent of the variation in the dependent variable, net cash operating income, is accounted for by the model.

The signs of the variables in Equation 1 are all as would have been expected. The first variable in this equation is total farm receipts. The sign of the variable is positive indicating a direct relationship with net farm income. A value of .74596 indicates that for a dollar increase in total farm receipts, net farm income increases by .74596 dollars. The t-value of the variable is 17.26 indicating a high degree of significance.

The second variable of the first equation is total farm expense. The sign of this variable is negative, signifying an inverse relationship with net cash operating income. The value of the coefficient is -0.80312, implying net cash operating income decreases for each dollar increase in total farm expense. The t-value of this equation is -13.92, indicating a high level of significance.

The final variable of Equation 1 is total capital purchases. The sign of this variable is negative, indicating an inverse relationship with net cash operating income. The estimated value of this variable is -0.64572, which

TABLE 1. RESULTS OF SIMULTANEOUS EQUATION ESTIMATION

Variable	Net Farm Income	Total Farm Receipts	Nonfarm Income	Total Liabilities	Total Assets	Total Capital Purchases	Total Farm Expense
Intercept	-6,649.83	32,083	5,936	125,968	324,027	-6,240	37;075
	(-2.48)	(3.51)	(3.71)	(8.22)	(13.09)	(-2.13)	(5.82)
Total assets		0.14401		0.27417			0.11145
		(8.69)		(8.32)			(9.52)
Total farm receipts	0.74596					0.45511	
	(17.26)					(14.55)	
Nonfarm income		-1.17679			2.38051	0.33994	-0.54847
		(-3.51)			(1.74)	(2.99)	(-2.10)
Total farm expense	-0.80312					-0.46635	
	(-13.92)					(-9.59)	
Family living expense		2.93718	0.18921				
		(7.94)	(2.69)				
Total capital purchases	-0.64572		0.03694				
	(-9.80)		(1.36)				
Net farm income			-0.10144	-0.93716	3.7052		
			(3.83)	(-3.37)	(7.16)		
R^2	.59	.53	.07	.24	.19	.53	.30

indicates net farm income decreases when total capital purchases rise. This variable is again significant with a t-value of -9.80.

Total Farm Receipts

In Equation 2, total farm receipts is the dependent variable with the following independent variables: intercept, total assets, nonfarm income, and family living expense. The signs of the coefficients in Equation 2 are again as expected and consistent with financial theory.

The first variable in this equation is total assets. This variable has a positive sign, which indicates a direct relationship with the dependent variable, total farm receipts. The value of the coefficient for the total assets variable is 0.14401, so it would be expected that for an increase of one dollar in total assets there would be an increase of 0.14401 dollars in total farm receipts. The t-value of this variable is 8.69, indicating a high level of significance.

The next variable in Equation 2 is nonfarm income. This variable has a negative sign indicating an inverse relationship. In addition, the value of the coefficient exceeds 1.0, which implies a competitive relationship with farm income.

The final variable in this equation is family living expense. This variable has a positive sign, which indicates a direct relationship with total farm receipts. The value of this variable's coefficient of 2.93718 implies that total farm receipts must increase by 2.93718 dollars for every dollar increase in family living expense. With a t-value of 7.94, this variable is highly significant.

Nonfarm Income

Equation 3 has nonfarm income as the dependent variable and independent variables family living expense, total capital purchases, and net cash farm operating income. The R^2 value for Equation 3 is .0769. This R^2 is low, and only 7 percent of the variation in the dependent variable, nonfarm income, is explained by the independent variables in the equation. However, the signs of the variables in Equation 3 are consistent with existing theory.

The first variable in this equation is family living expenses. The sign of this variable is positive and indicates a direct relationship with the dependent variable. Therefore, as family living expenses increases by one dollar, nonfarm income would have to increase by .18921 dollars.

The second variable of this equation, total capital purchases, has a positive sign indicating a direct relationship with nonfarm income. If total capital purchases were to increase by one dollar, the value of nonfarm income would likely increase by .03694 dollars.

The next variable in Equation 3 is net cash farm operating income. The sign of this variable is negative, which implies that nonfarm income substitutes for cash operating income shortfalls.

Total Liabilities

Equation 4 has total farm liabilities as the dependent variable; the independent variables consist of the intercept, total assets of the farm, and net cash farm operating income. The signs of the variables in Equation 4 are consistent with theory.

Total assets was the first variable to enter in the equation. The sign of this variable is positive and indicates a direct relationship with total farm liabilities. The value of the coefficient is .27417. Thus, each new dollar of asset purchase is financed with this amount of debt. This variable is significant with a t-value of 8.32.

The last variable in this equation is net cash farm operating income. The sign of this variable is negative and indicates an inverse relationship with total liabilities. A dollar increase in net cash farm operating income results in a -0.93716 paydown of liabilities.

Total Assets

Equation 5 has as its dependent variable total farm assets. Independent variables for Equation 5 consist of the intercept, net cash farm operating income, and nonfarm income. The R^2 for Equation 5 is .1875.

The first variable of this equation is nonfarm income. It has a positive sign, indicating a direct relationship with farm assets. As nonfarm income increases by one dollar, total assets rise by 2.38051.

The second variable in this equation is net cash farm operating income. The sign of the variable is positive, indicating a direct relationship with total assets. For each dollar increase in net cash farm operating income there would be a 3.7052 dollar increase in the total asset level of the farm. This variable is significant with a t-value of 7.16.

Total Capital Purchases

The dependent variable for Equation 6 is total capital purchases. Independent variables for Equation 6 are the intercept, total farm receipts, nonfarm income, and total farm expense. The R^2 value for Equation 6 is .5311. The variable signs for this equation are consistent with theory.

Total farm receipts, which has a positive sign, is the first variable in Equation 6. The direct relationship shown here means that for a dollar increase in total farm receipts there would be an increase of .45511 dollars in total capital purchases. This variable has a high level of significance with a t-value of 14.55.

Nonfarm income, the second variable in Equation 6, has a positive sign and indicates a direct relationship with total capital purchases. A dollar increase in nonfarm income would be reflected in a .33994 dollar increase in total capital purchases. This variable is significant with a t-value of 2.99.

The last variable in this equation is total farm expense. This variable has a negative sign, which signifies an inverse or competitive relationship with the dependent variable, total capital purchases. As the value of total farm expense increases by one dollar, the amount of total capital purchases decreases by -0.46635 dollars.

Total Farm Expense

The dependent variable in Equation 7 is total farm expense. Independent variables consist of total assets, and nonfarm income. The R^2 value for Equation 7 is .2965. The variable signs for Equation 7 are consistent with theory.

The first variable in Equation 7 is total farm assets. With a positive sign, it would be expected that as total farm assets increase by one dollar, total cash farm operating expense less interest would increase by .11145 dollars. The t-value for this variable is 9.52, indicating a high degree of significance.

The other variable in this equation is nonfarm income. This variable has a negative sign, and this indicates that there is an inverse relationship between nonfarm income and total farm expense. As the value of nonfarm income increases by one dollar, total farm expense would decrease by -0.54847 dollars.

Interpretation of Simultaneous Equation Results

This section interprets the model results. A feel for the simultaneity involved in the financial management decision process can best be described with two examples.

Beginning with net cash operating income in the first equation, the overall secondary effects on the other variables are described below, in sequence, to illustrate the simultaneity involved. In the first example, it is assumed total farm expense increases by $10,000. The effect of this increase is traced through all seven equations to illustrate whole farm effects.

In Equation 1, net farm cash operating income would decrease by $8,031. In other words, as expenses go up net income for the farm is decreased.

In Equation 6, the $10,000 increase in total farm expense would cause a decrease in capital purchases of $4,663. Since the farmer's expenses are increasing, it leaves him with less money in new capital purchases.

The effects of less capital purchases would also have the effect of increasing net farm income in Equation 1 by $3,011. This increase in net farm income from less capital purchases could be used to reduce the liability level of the farm.

The decrease of $8,031 in net farm income would cause an increase of $815 in nonfarm income. The farmer, or a member of his family, might increase their work off the farm to make up for the decrease in net cash operating income.

This completes an example on the simultaneity involved in the whole farm decision-making process. A second example can further explain this process.

A second example makes an assumption of a $10,000 increase in total farm receipts. The effects are traced through all seven equations. The $10,000 increase in total farm receipts results in an increase of $7,459 in net cash farm operating income in Equation 1. This would be a natural occurrence from the increase in total farm receipts.

Equation 6 shows the results of a $10,000 increase in total farm receipts. There would be an increase in total capital purchases of $4,551. The farm operator would invest in additional capital purchases with the addition to total farm receipts.

The increase in total capital purchases would cause an increase in nonfarm income of $168. If the increase in total farm receipts is spent on new capital purchases, nonfarm income would increase to help pay some other expenses as will be seen in the next step.

The increase in nonfarm income of $168 would cause a decrease of $92 in total farm expense. As indicated in the previous paragraph, the increase in total farm receipts is spent on capital items, therefore nonfarm income increases to pay some of the other farm expenses. This would have the impact of reducing the level of liabilities on the farm.

Now it can be seen how these selected financial variables have a simultaneous relationship with each other and with other variables. In other words, a change in one of the variables in the eight equations has an impact on all eight equations. This model therefore shows the importance of looking at the simultaneity of these relationships when evaluating farmers' decisions.

Conclusion

Results of this study show substantial simultaneity exists between key financial variables on North Dakota farms. In addition to primary effects, agricultural economists must also consider secondary effects when optimal financial management practices are recommended. Previous research has investigated these variables independently.

The study emphasizes the need for strong financial management skills on the part of farmers. The degree of simultaneity among key decisions in the management process illustrates the complexity of farm financial management. Farmers must have complete records and sufficient education in order to make informed decisions.

There are several limitations of this study. First, results of the study are limited because variables describing uncertainty and the life cycle of farm units was unavailable. Consideration of these factors would improve the analysis. Moreover, the database was limited to six years of observations. During this time period, agriculture experienced significant financial stress. This situation may have biased the findings of this study. For these reasons, further study of farmers' financial management practices appears warranted.

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