Credit Scoring, Loan Pricing, and Farm Business Performance

Peter J. Barry and Paul N. Ellinger

In light of recent developments in agricultural credit evaluations, this study employs a multiperiod simulation model that endogenizes farm investment decisions, credit evaluations, and loan pricing based on the credit scoring procedures of agricultural lenders. Model results show that credit-scored pricing yields time patterns of performance, credit classifications, and interest rates that parallel the firm's investment, financing, and debt servicing activities. Moreover, the lender's price responses dampen growth incentives as credit worthiness diminishes, stimulate growth as credit improves, and lead to similar capital structures over time.

Key words: credit, credit scoring, loan pricing, farm performance.

The combined effects of financial stress in agriculture, deregulation of interest rates in financial markets, and improved information systems for lenders have brought significant changes in credit evaluations, risk assessment, and pricing policies in agricultural lending. Loan evaluation at the customer level is receiving greater emphasis and loan pricing increasingly is tailored to the risk characteristics of individual farm borrowers (Barry and Calvert). It has become common, for example, to observe lenders who categorize borrowers into several risk classes with higher interest rates associated with higher risk classes (Schmiessing et al.; Lufburrow, Barry, and Dixon). These changes in the scope of risk assessment and in the form of the lender's response provide a new setting for evaluating the relationships among the lender's credit evaluation, the terms of financing, and the borrower's business performance.

Our purpose in this paper is to identify and evaluate the linkages over time between business performance and financing terms in a modeling approach that endogenizes farm investment decisions, credit evaluation, and loan pricing based on the credit scoring procedures of commercial lenders. A multiperiod model is developed to evaluate these linkages for a representative farm situation under alternative investment strategies, economic conditions, and beginning financial positions. In the following sections we further develop the concepts and review the literature about credit relationships and loan pricing in agriculture, describe the modeling approach, discuss the analysis and the results, and consider the implications for agricultural finance.

Credit Concepts and Evaluation Procedures

Previous studies of credit relationships in agriculture have shown that the responses of lenders to the business characteristics and managerial actions of farmers influence a farmer's total cost of borrowing through the combined effects of the interest rate on borrowed funds and a liquidity premium reflecting the borrower's subjective valuation of credit held in reserve as a source of liquidity (Barry, Baker, and Sanint; Barry and Baker; Chhikara). In turn, these cost effects may influence the optimal financial structure (leverage) and rate of growth of a farm business as well as the composition of its assets, risk management practices, and other income generating activities (Baker; Barry and Willmann; Pflueger and Barry; Sonka, Dixon, and Jones). However, these studies mostly have focused on measuring the nonprice responses of lenders, especially limits on credit availability, in a static

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setting with less attention given to the lender's process of credit evaluation, including the relative importance of the major variables affecting credit worthiness.

In contrast, a growing set of studies (Lufburrow, Barry, and Dixon; Dunn and Frey; Hardy and Weed; Fischer and Moore; Stover, Teas, and Gardner) have focused on the credit evaluation process, including the development and validation of various types of credit scoring models. Credit scoring provides a systematic, comprehensive way in which to assess the borrower's financial data and, along with the lender's judgment and other relevant information, reach a valid assessment of the borrower's credit worthiness. The basic steps are to identify key variables that best distinguish among borrowers' credit worthiness, choose appropriate measures for these variables, weight the variables according to their relative importance to the lender, and then score each loan as a weighted average of the respective variables. The credit evaluation results then may serve as the basis for risk-adjusted loan pricing, as well as for assessing the quality of loan portfolios, validating loan decisions to other loan personnel and regulators, screening loan applicants, and counseling with borrowers.

But credit scoring studies also have been static in nature; they have given little attention to how the credit score would respond to selected risk responses of borrowers, to changes in borrower performance over time, or to the relationship between the resulting credit score and the price and nonprice terms of financing. Thus, neither set of studies has integrated the multiperiod analysis of business performance with the lender's methods of loan pricing, where loan pricing is based on credit evaluations resulting from this performance, in order to evaluate their joint effects. This study focuses on the joint treatment of these relationships under the premise that this approach will yield more valid projections of farmers' future financial performance, given lenders' greater use of adjustments in loan pricing as a response to changes in a borrower's credit worthiness.

Modeling Concepts

To illustrate the linkages among business performance, credit scoring, and loan pricing, we will initially abstract from the details of risk and time by using a simple profitability model in which the borrower's rate of return (r_e) on equity capital is expressed as the weighted average of the difference between the return on assets (r_a) and the cost of debt (i), where the weights are the ratios of assets to equity (A/E) and debt to equity (D/E), respectively, and the profitability measure is net of the withdrawals for taxation (t) and consumption (c):

$$(1) \quad r_e = [r_a (A/E) - i(D/E)](1 - t)(1 - c).$$

In turn, the interest rate on debt is a function of the lender's cost of acquiring loanable funds (i_f), the fixed costs of administering the loan program (i_a), and a risk premium (i_r) attributed to the credit worthiness and related lending costs of individual borrowers (Lee and Baker):

$$(2) \quad i = f(i_f, i_a, i_r).$$

Assuming the lender uses the pool-of-funds approach to funding individual loans (Hayes) and allocates fixed lending costs among borrowers in proportion to their loan volume—both of which are typical in agricultural lending (Barry and Calvert; Barry, Baker, and Sanint)—then the differences in interest rates among borrowers are due primarily to differences in credit worthiness.[1] Moreover, if credit worthiness is evaluated on the basis of systematic, consistent procedures of credit scoring, then the differential risk premium (i_r) is a function of the variables and weights that comprise the credit score. That is,

$$(3) \quad i_r = f(CREDIT\ SCORE)$$

in which

$$(4) \quad CREDIT\ SCORE = f(aX_1, a_2X_2, \ldots, a_nX_n),$$

where X_n is the set of credit worthiness variables and a_n is the set of weights on the variables.

To illustrate the analytical effects of differential pricing on the borrower's financial structure, assume that the credit score (and thus the loan rate) is a function of only one variable—the borrower's leverage position as measured by the debt-to-equity ratio (D/E). Moreover, let the relationship be a linear function so that $i = i_{fa} + b(D/E)$ where i_{fa} is the base rate determined by the funding and administrative

[1] One exception occurs when loan pricing from a commercial bank directly reflects the borrower's deposit relationship with the bank. In this case the loan rate may reflect the combined effects of credit worthiness and the level of deposits held on account at the bank.

costs and b is the rate response to a one-unit increase in leverage. Substituting $i = i_{fa} + b(D/E)$ and $A/E = D/E + 1$ into equation (1), expanding terms, and deleting the consumption and tax components yields

$$(5)\quad r_e = [r_a(D/E) + r_a - i_{fa}(D/E) - b(D/E)^2].$$

If the objective is to maximize r_e by treating D/E as the decision variable, then differentiating (5) with respect to D/E, equating the result to zero, and solving for D/E gives optimal leverage of

$$(6)\qquad D/E = \frac{r_a - i_{fa}}{2b}.$$

Optimal leverage then is positively related to changes in the returns on assets and negatively related to changes in the base rate and leverage parameter.

In contrast, the traditional framework in which no differential pricing based on credit scoring occurs would maximize (1) subject to a nonprice constraint imposed by the lender on the maximum D/E. Without risk considerations or other nonlinearities in returns or borrowing costs, the maximization of (1) would push leverage to the limit.

In practice, of course, credit scoring usually is based on multiple variables whose weights vary among lenders. The major variables determining credit worthiness generally include a borrower's profitability, liquidity, solvency, collateral position, and repayment ability (e.g., Lufburrow, Barry, and Dixon). The exact weights are an empirical question that may vary among lenders. However, the characteristics of loan contracts involving the required repayment of loan principal and the fixed interest obligation generally suggest that lenders will emphasize loan safety and repayment more than the borrower's expected profitability, because the lender does not share directly in the borrower's profits.

Finally, the tendency for lenders to group their borrowers into a few discrete classes for pricing, credit evaluation, and monitoring suggests that the credit score and resulting risk premium become discrete and ordinally ranked variables. Thus,

$$(7)\quad i_r = \begin{cases} i_{r1} \text{ if } CREDIT\ SCORE > CS_1 \\ i_{r2} \text{ if } CS_2 < CREDIT\ SCORE < CS_1 \\ \vdots \\ i_{rn} \text{ if } CS_n < CREDIT\ SCORE < CS_{n-1} \end{cases}$$

where CS_n indicates the cut-off score between the various credit classes.

A significant feature of these variables is the interrelationships that occur over time among business performance, the credit score, and loan pricing. In principle, the credit score (and thus the loan rate) should depend on both the firm's current financial position and projected performance. In addition, as time passes, the credit score will change as changes occur in current and projected performance, some of which are intended changes while others result from the effects of unanticipated random factors. However, modeling such simultaneous and dynamic relationships would yield a highly complex framework that also would be subject to the quality of the projections. Moreover, lenders themselves fall considerably short of this level of sophistication because most of their credit evaluations and the credit scoring models in use are based on data about the borrower's past and present financial position rather than long-term projections of financial performance. When projections are used, mostly they reflect anticipated outcomes for a single year or constant levels of farm performance and interest rates over longer periods of time.

Thus, the temporal relationships among credit scoring, loan pricing, and business performance can be plausibly modeled in a recursive framework in which the lender's credit decisions affecting the borrower's future financing terms are based on the firm's current financial position which in turn is determined by past performance. That is, the lender is assumed to base credit decisions on expected outcomes in the context of a firm's current financial structure which itself is based on past experiences.

The recursive framework is portrayed by the flow chart in figure 1. At the start of period 1, the financial position of the borrower's firm is described in terms of its size, tenure position, and structure of assets, liabilities, and equity capital, along with various performance measures reflecting the outcomes of previous operations. The borrower then formulates the business plans for the coming year including intended decisions about production and marketing activities, acquisition of operating inputs, investment plans and capital transactions, withdrawals for consumption and taxation, financing needs, and anticipated debt servicing. The lender responds to the business plans and financing requests by evaluating the firm's credit worthiness using a credit scoring technique. Based on the credit evaluation, the

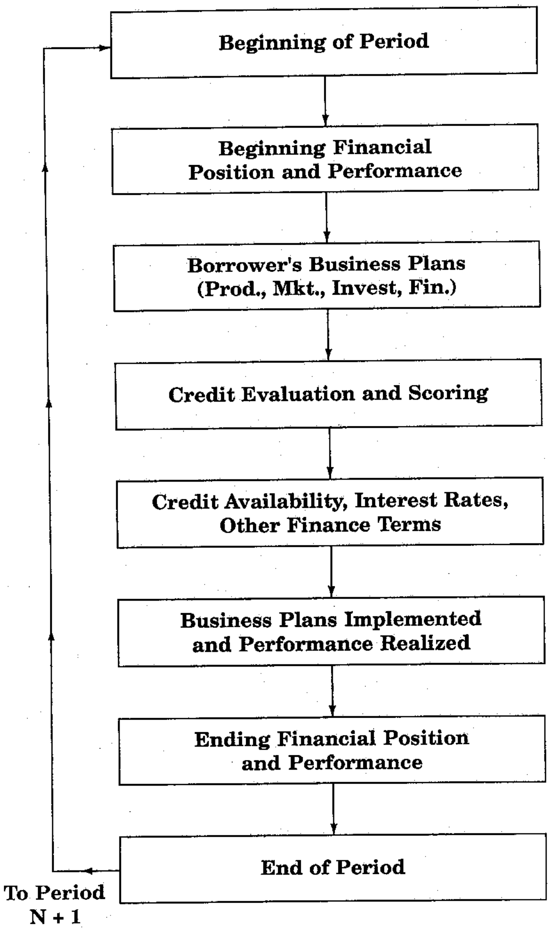

Figure 1. Credit evaluation process and loan pricing

lender and borrower may modify the plans and eventually agree on the availability of various types of credit, the levels of interest rates, collateral requirements, loan maturities, and other financing terms. The borrower then implements the business plans, carries on the firm's activities over the period, and realizes the resulting performance. The ending financial position accounts for the combined effects of the beginning position, the business plans, the credit terms, and the subsequent outcomes. Finally, the ending position becomes the beginning position for the next period, in which the process is repeated, and this sequence continues until the horizon is reached.

Methodology

The recursive process presented in the preceding section could be implemented using simulation or optimization procedures. Optimization offers the opportunity to observe financial performance, investment patterns, and financing activities that arise from the firm's efforts to push against its resource limits and operating requirements in order to maximize the stipulated objectives. However, a mathematical programming approach suffers from difficulties in endogenizing a credit scoring function in which the variables are expressed by financial ratios and from a less flexible approach for testing the effects of alternative investment strategies, parameter specifications, and environmental conditions.

Accordingly, a recursive, multiperiod simulation model is formulated for use in this study in order to portray the firm's financial setting and business opportunities. The model is formulated, using the LOTUS 123 spreadsheet software, as a series of annual business decisions and performance results with integer specifications on major business investments. The periods are linked together by financial transfers from one period to the next and by the credit scoring procedure in which the firm's cost of borrowing is determined by its financial position at the end of the preceding period which itself reflects the cumulative effects of past performance. Thus, the model resembles the basic approach of other commonly used simulation models (Richardson and Nixon; Walker and Helmers; Schnitkey, Barry, and Ellinger), except for the annual updating of the credit scoring and loan pricing mechanism, a deterministic specification, and less empirical detail on production and marketing components.

A deterministic model is specified in order to highlight the relationships among business plans, financial performance, the credit score, and borrowing costs. That is, values for gross receipts, operating costs, growth rates, and other parameters are all expressed by single-valued expectations. A stochastic framework would add further realism, including the provision for alternative risk attitudes and methods of responding to risk; however, the added complexities would obscure the key relationships and might yield performance measures (e.g., variance of income or wealth, probability of loss, probability distributions) that are not directly reflected in credit scoring procedures used by lenders.

Model Components

The model's components include the firm's initial financial position, operating decisions, investment alternatives and liquidity requirements, performance measures, and the credit scoring and loan pricing mechanism. The asset structure of the firm's initial balance sheet contains cash, marketable securities, crop inventories, machinery and equipment, securities not readily marketable, buildings, land, and other fixed assets. The initial debt structure is determined by a specified debt-to-asset ratio, average maturities for intermediate- and long-term debt, and the proportions of current, intermediate-, and long-term debt.

Purchases of machinery, buildings, and land can occur in any year, based on the liquidity requirements described below. Economic depreciation rates are specified for machinery and buildings. Gross returns, direct costs, and overhead costs are entered for owned and leased land on a per-acre basis, including any allocation between landlord and tenant on share-leased land. Growth rates can be entered for revenues, costs and values of machinery, buildings, and land. Costs per acre can also be adjusted as farm size changes to reflect economies or diseconomies of size.

The model is formulated to permit land purchases when a specified liquidity requirement is met. Specifically, land purchases will occur in integer units each year as long as the measure of accumulated fund availability exceeds the sum of the down payment requirement on the land purchase plus a liquidity factor or "cushion" that is specified as a percent of the down payment.[2] Besides land, an alternative investment is the allocation of funds to marketable securities. Thus, the model has a growth orientation, subject to a liquidity requirement that can be adjusted to reflect the preferences of the decision maker. Other input specifications include the price of land and the incremental size (40 acres, 80 acres, etc.) of the purchase units.

Output measures include an annual series of financial statements from which a set of financial ratios representing profitability, liquidity, and solvency is calculated. Other output includes the annual credit score, credit classification and interest rate, and other descriptive information.

The numerical specifications of the model follow. Initial assets include cash, $10,000; marketable securities, $10,000; crop inventory, $93,375; machinery, $100,000; retirement accounts, $20,000; buildings, $30,000; and land and other, $350,000. Operating debt, including the current portion of intermediate- and long-term debt and accounts payable within the next year, is specified as 20% of total debt. Intermediate-term debt is specified as 20% of total debt with a four-year maturity. Long-term debt is 60% of total debt with a 20-year maturity. The farm owns 200 acres valued at $1,750 per acre and rents 500 acres on a 50-50 crop share basis. Gross returns begin at $415 per acre and cash operating costs are $228 per acre. Machinery purchases for annual replacements are $23 per acre. Land purchases are accompanied by additional machinery investments of $180 per acre and buildings investments in the amount of 5% of the land purchase. Family withdrawals start at $20,000 per year and grow at 3% per year, tax exemptions are four, and the rate of return on marketable securities is 6%.

Credit Scoring and Loan Pricing Components

As indicated earlier, a wide variety of worksheets, scoring methods, and evaluation mechanisms are employed by agricultural lenders ranging from relatively simple checksheet approaches based on judgment and subjective evaluations to statistically based credit scoring that utilizes financial data. Regardless of the specific approach, the basic concepts are essentially the same in all these evaluation mechanisms; that is, to identify, measure, and weight the key variables considered to reflect a borrower's credit worthiness and aggregate the results into an overall credit score.

The credit scoring model employed here is patterned after those currently used by the St. Louis and Louisville Farm Credit Banks as a basis for classifying and pricing operating and intermediate-term loans to agricultural borrowers (Farm Credit Banks of St. Louis; Bieber; Tongate). The variables are essentially the same, except a current ratio is used in place of a collateral ratio and uniform weights are used on each variable. In addition, the model is applied to pricing real estate loans as well as non-real estate loans. The variables include: 1) solvency, as measured by the debt-to-asset ratio; 2) liquidity, as measured by the current ratio; 3) cash flow, as measured by a debt servicing ratio; 4) profitability, as measured by

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[2] Fund availability is defined as the sum of net income plus depreciation and outside earnings minus withdrawals, down payments, and principal payments. Accumulated fund availability equals the total of available funds carried forward from prior years.

Table 1. Credit Scoring and Loan Pricing Model

Variable	Measure	Weight	Range	Score
Solvency	Ratio of debts to total assets	20%	0.00–0.20	0
			0.21–0.40	10
			0.41–0.60	20
			above 0.60	30
Liquidity	Current ratio	20%	above 3.00	0
			1.51–3.00	10
			1.00–1.50	20
			under 1.00	30
Cash Flow	Debt servicing ratio (Interest plus scheduled principal payments plus 25% of any working capital deficit all divided by crop and livestock sales)	20%	under 0.15	0
			0.16–0.25	10
			0.26–0.35	20
			above 0.35	30
Profitability	Rate of return on assets	20%	above 0.08	0
			0.04–0.079	10
			0.01–0.039	20
			under 0.01	30
Debt exposure	Value of farm production plus nonfarm income divided by total liabilities	20%	above 1.20	0
			0.81–1.20	10
			0.40–0.80	20
			0.00–0.40	30

Credit classification	Scoring range	Interest rate
Class 1	0–7.5 points	8%
Class 2	7.6–15.0 points	10%
Class 3	15.1–22.5 points	12%
Class 4	above 22.5 points	14%

the rate of return on assets; and 5) debt exposure, as measured by gross earnings divided by total liabilities. The variables, measures, weights, and resulting credit classes are shown in table 1.

The borrower's interest rate on loans is determined by the credit score and classification procedure. The approach followed here for assigning a specific interest rate to each credit class is to specify a base rate and an interest-rate range around the base rate. Since four credit classes are used, the four interest rates are determined by adding and subtracting 50% and 150% of the interest-rate range to and from the base rate. If, for example, the base rate is 11% and the range is 2%, then the set of interest rates is as follows: Class 1, 8% (11% − 1.5*2); class 2, 10% (11% − .5*2); class 3, 12% (11% + .5*2); class 4, 14% (11% + 1.5*2). This procedure is easily specified in the simulation model and allows straightforward changes in the base rate, range, multiplying factors, and weights on variables, if desired.

Design of Empirical Analysis

The empirical analysis is designed to show the effects of the credit scoring and loan pricing mechanism relative to constant pricing under different specifications on the initial leverage position, growth rates, down payment levels, and liquidity requirements. Extensions of the analysis also consider the effects of alternative weightings of the credit scoring variables and different integer specifications on land purchases. The goals are first to observe the response of the firm's simulated performance to the adoption of credit-scored pricing. Then the effects of alternative leverage positions, economic conditions, and other variations are considered.

The adoption of credit-scored pricing is expected to yield time patterns of performance, credit classifications, and interest rates that parallel the changes in the firm's financial position arising from its investment, financing, and debt servicing activities. That is, a growth-oriented firm starting in a relatively low leverage and strong liquidity position should have a favorable credit rating and relatively low interest rates. Growth (through land acquisition in this case) will occur relatively rapidly and in larger amounts until the increased financial risk and reductions in liquidity yield a reduced credit rating, higher borrowing costs, and thus reduced incentive for further growth.

Conversely, a growth-oriented firm starting in a relatively high leverage and low liquidity position will have a less favorable credit rating and higher borrowing costs. Growth will tend to be delayed and diminished until the variables determining the credit rating change sufficiently to yield an improved credit score and lower borrowing costs.

These anticipated performance patterns are consistent with the insight provided by finance theory. If the rate of return on assets exceeds the cost of borrowing, then higher financial leverage increases the expected rate of return to equity capital, although total risk increases as well. Under constant values for borrowing costs and asset returns, only nonprice credit responses by lenders would limit financial leverage and thus growth potential. Including the price response of the lender in the analysis through adjustments in interest rates as credit worthiness changes will provide an internal control mechanism that dampens the incentive for growth as credit worthiness diminishes and stimulates growth as credit conditions strengthen. In this fashion, the lender response serves as an equalizing factor for growth-oriented farms starting in different credit positions and should yield near equality among the ending capital structures, credit classifications, and the return on assets and borrowing costs, after accounting for the discrete price intervals and under the deterministic conditions assumed here.

Similar response patterns are anticipated under alternative economic conditions. Real growth in earnings and asset values will improve credit, reduce borrowing costs, and stimulate growth and financing until the interest rate response to diminished credit worthiness occurs. Conversely, real negative growth in earnings and asset values will diminish credit, raise borrowing costs, and thus dampen the incentive for growth.

Empirical Results

The results of the simulation analysis, conducted over a 10-year horizon, are consistent with the anticipated patterns of response described above. In table 2 selected model results are shown for each of the 10 years for alternative values of the initial debt-to-asset ratio, growth rates, and the presence and absence of credit-scored loan pricing. Section I of table 2 shows that, in the absence of credit-scored pricing and with a beginning debt-to-asset ratio of 30%, net worth grows by 123.33% by the end of the horizon, 160 acres are purchased beginning with a 40-acre purchase in year 4, and the credit classification and scores show a strengthening from class 2 to class 1 in years 2 and 3 and then a return to class 2 as land investments and financing occur.

The introduction of credit-scored pricing, as shown in section II of table 2, allows the firm to begin with interest rates of 10% in year 1 which then decline to 8% in years 2 through 6. These relatively low rates in turn contribute to improved financial performance and a longer tenure in credit class 1, even with an acceleration in land investments. Following the initial 40-acre land investment in year 4, subsequent land purchases occur one year earlier than in the absence of credit-scored pricing and include an additional 80-acre purchase in year 10, bringing total purchases to 240 acres. The added investments and financing increase the interest rates to 10% for years 7 through 10. Net worth grows by 139.22% over the 10-year period, and while the ending debt-to-asset ratio of 34.5% is higher than that of the section I case, the ending credit score still yields a class 2 credit classification.

Section III of table 2 reflects a more favorable economic environment in which farm income and land values grow at a 5% annual rate compared to annual growth rates of 3% for operating and other costs. As expected, net-worth growth increases to 251.84%, and land purchases increase to 360 acres. The credit scores, classifications, and interest rates follow the same patterns as in section II of the table. That is, credit worthiness improves to class 1 in the early periods and then returns to class 2, reflecting the financial consequences of the additional land investments.

The model specifications in section IV of table 2 are the same as those of section III except for an increase in the initial debt-to-asset ratio from 30% to 60%. (Since total assets are the same in both cases, the increase in leverage implies a lower level of beginning net worth.) The high initial leverage along with less favorable values for the other credit variables pushes the year 1 credit score into class 4 with a high interest rate of 14%. As debts are repaid, leverage is reduced, and other credit variables strengthen in response to the growth in farm income and land values, the credit score improves and the credit classification improves as well, to class 3 in year 3, class 2 in year 6,

Table 2. Annual Simulation Results with and without Credit-Scored Pricing under Alternative Growth Rates and Beginning Leverage Positions

Year	1	2	3	4	5	6	7	8	9	10	Total
I No price response; D/A, 30%; growth rates, 3%											
Net worth change, cum %	7.34	15.85	24.81	35.80	46.65	59.72	72.80	88.36	105.69	123.33	
Return on assets, %	7.93	8.20	8.11	9.34	8.40	9.44	8.60	9.50	9.67	8.94	
Return on equity, %	7.08	7.62	7.47	8.40	7.69	8.53	7.87	8.61	8.80	8.22	
Debt to assets, %	27.7	24.7	23.3	27.6	26.1	29.3	27.7	30.1	32.0	30.1	
Land purchases, acres	0	0	0	40	0	40	0	40	40	0	160
Credit score	10	6	4	8	8	8	8	8	8	8	
Credit class	2	1	1	2	2	2	2	2	2	2	
Interest rate, %	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	
II Price response; D/A, 30%; growth rates, 3%											
Net worth change, cum %	7.72	16.53	26.42	38.65	52.64	66.69	83.55	101.06	118.85	139.22	
Return on assets, %	7.93	8.14	7.95	9.10	9.30	8.44	9.27	9.54	8.82	9.62	
Return on equity, %	7.43	7.86	8.14	9.23	9.60	8.80	9.63	9.10	8.48	8.89	
Debt to assets, %	27.5	24.6	23.1	27.2	30.3	28.4	30.6	32.4	30.4	34.5	
Land purchases, acres	0	0	0	40	40	0	40	40	0	80	240
Credit score	10	6	4	6	6	6	8	8	8	8	
Credit class	2	1	1	1	1	1	2	2	2	2	
Interest rate, %	10.0	8.0	8.0	8.0	8.0	8.0	10.0	10.0	10.0	10.0	
III Price response; D/A, 30%; growth rates: operating and other costs 3%, farm income and land values, 5%											
Net worth change, cum %	9.40	20.87	34.50	52.17	73.59	99.29	129.85	164.54	201.45	251.84	
Return on assets, %	7.93	9.69	9.90	11.45	11.89	12.20	12.42	13.05	11.90	14.05	
Return on equity, %	8.98	9.96	10.68	12.32	13.15	13.79	14.24	14.03	13.04	15.43	
Debt to assets, %	27.2	24.0	22.2	26.0	28.6	30.3	31.2	34.3	31.5	35.7	
Land purchases, acres	0	0	0	40	40	40	40	80	0	120	360
Credit score	10	6	4	4	6	6	8	8	10	10	
Credit class	2	1	1	1	1	1	2	2	2	2	
Interest rate, %	10.0	8.0	8.0	8.0	8.0	8.0	10.0	10.0	10.0	10.0	
IV Price response; D/A, 60%; growth rates: operating and other costs, 3%; farm income and land values, 5%											
Net worth change, cum %	6.06	15.63	27.82	45.49	66.66	92.33	125.52	170.41	230.16	297.04	
Return on assets, %	7.93	11.54	12.03	12.26	12.62	13.14	13.66	15.22	16.30	14.68	
Return on equity, %	5.88	8.64	10.01	12.93	13.56	14.30	15.89	18.10	19.90	18.40	
Debt to assets, %	58.9	56.9	54.3	50.1	45.2	39.4	31.9	32.7	38.0	32.1	
Land purchases, acres	0	0	0	0	0	0	0	40	80	0	120
Credit score	24	24	22	18	18	12	6	6	6	8	
Credit class	4	4	3	3	3	2	1	1	1	2	
Interest rate, %	14.0	14.0	12.0	12.0	12.0	10.0	8.0	8.0	8.0	10.0	
V Price response; D/A, 30%; growth rates: operating and other costs, 3%; farm income and land values, −1%											
Net worth change, cum %	4.34	8.07	11.02	13.95	14.90	14.76	12.75	9.34	4.42	−2.19	
Return on assets, %	7.93	4.99	3.90	4.28	2.87	2.18	1.68	1.03	0.38	−0.28	
Return on equity, %	4.25	3.52	2.69	2.60	0.83	−0.13	−1.77	−3.07	−4.60	−6.54	
Debt to assets, %	28.0	25.9	25.1	30.6	29.7	29.5	30.4	32.3	35.2	39.1	
Land purchases, acres	0	0	0	0	40	0	0	0	0	0	40
Credit score	8	6	6	6	6	10	12	12	14	20	
Credit class	2	1	1	1	1	2	2	2	2	3	
Interest rate, %	10.0	8.0	8.0	8.0	8.0	10.0	10.0	10.0	10.0	12.0	

and class 1 in years 7, 8, and 9. In turn, the declining pattern of interest rates contributes to the improved financial performance and credit worthiness, so that the net effect is a greater percentage change in net worth at the end of the horizon for the higher initial leverage case than for the lower initial leverage case. Land purchases are diminished and delayed relative to the section III results, but the two farm situations end the period with similar leverage positions and credit classifications. Thus, the differences in initial capital structures and credit classifications are diminished substantially over time as the firm's investments and financing transactions respond to the respective patterns of the credit classifications and interest rates.

Section V of table 2 retains the initial debt-to-asset ratio of 30%, but reflects an unfavorable economic environment in which farm revenue and land values decline at a 1% annual rate, compared to an annual growth rate of 3% for operating and other costs and the nominal interest rates. A 40-acre land purchase occurs in only one year and net worth remains relatively stagnant over the horizon. The reductions in investments and related financing requirements help to maintain a relatively favorable credit classification until deterioration occurs in year 10. Thus, the farm maintains relatively low interest rates but at the expense of business growth and improved financial performance.

In table 3, the focus shifts to reporting selected measures of the farm's financial position, land investments, and credit classifications at the end of year 10 (the final year of the horizon) for initial debt-to-asset ratios ranging from 0% to 70% and for different assumptions about the growth rates of farm income and land values. In section I of the table with the 3% growth in farm income and land values, land purchases tend to decline as leverage increases, consistent with the more favorable credit conditions early in the horizon that were demonstrated in comparing sections III and IV in table 2. However, the ending credit classifications and interest rates are the same, except for the highest leverage case, and the percentage changes in net worth as well as the debt-to-asset ratios lie in a relatively narrow range, at least until the higher leverage classes are reached. In this case, an initial debt-to-asset ratio of 70% is high enough to keep the firm from attaining any meaningful improvement in performance over the 10-year period.

The more favorable economic environment in section II of table 3 indicates a larger percentage change in ending net worth and greater land investments, although ending capital structures, credit classifications, and interest rates are very similar across the leverage positions and in comparison to the section I results. The unfavorable economic environment in section III indicates a pattern of results similar to section II for initial debt-to-asset ratios of 20% or less. As initial leverage increases, financial performance and credit classifications quickly deteriorate and eventually reach a point of technical insolvency for the farm business.

Other variations of the analysis (not reported in the tables) considered the effects of changes in down payment and liquidity requirements, weights on credit variables, and size increments of land investments. Lowering the down payment from 35% to 20% of the purchase price tended to increase land purchases and leverage over the horizon and pushed the firm into higher credit classifications with higher interest rates. Increasing the down payment requirement had the opposite effect. In a similar fashion, incremental increases in the liquidity cushion from 50% to 200% of the down payment tended to reduce and delay land purchases, for a given initial leverage position, although the impacts on net-worth growth and credit classification were negligible.

The adjustment in the credit score involved increasing the weight on the debt-to-asset ratio from 20% to 50% and reducing the weights on the other four variables to 12.5%. This change reflects the practice of some lenders to place greater emphasis on the debt-to-asset ratio (or an equivalent measure of leverage). These changes yielded minor reductions and delays in the land investments and small reductions in net-worth growth across the various scenarios. Thus, for this particular change in the credit scoring model, the levels of the variables in the model are much more important than changes in the weights. Finally, increasing the size increment of allowable land purchases in 20-acre increments from 20 acres to 200 acres, for a given leverage position, had the effect of delaying land acquisition until sufficient finan-

Table 3. End-of-Year 10 Simulation Results under Alternative Growth Rates and Beginning Leverage Positions

	Beginning Debt-to-Asset Ratio							
	0.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0
I Price response; growth rates, 3%								
Net worth change, %	123.0	131.10	131.77	139.22	133.78	118.65	112.51	15.01
Return on assets, %	9.26	8.88	9.48	9.62	8.96	8.77	9.76	10.41
Return on equity, %	8.61	8.23	8.77	8.89	8.66	8.50	9.75	1.31
Debt to assets, %	32.0	33.0	34.0	34.0	30.0	29.0	34.0	73.0
Land purchases, acres	360	320	280	240	120	40	0	0
Year first purchased	3	3	3	4	5	8	0	0
Credit score	10	10	8	8	8	8	10	26
Credit class	2	2	2	2	2	2	2	4
Interest rate	10.0	10.0	10.0	10.0	10.0	10.0	10.0	14.0
II Price response; growth rates: operating costs, 3%; farm income and land values, 5%								
Net worth change, %	224.7	236.1	243.2	251.8	257.3	268.9	297.0	245.1
Return on assets, %	12.89	13.18	13.15	14.05	12.48	14.80	14.68	15.19
Return on equity, %	14.19	14.60	14.44	15.43	13.94	17.77	18.39	18.16
Debt to assets, %	35.0	35.0	34.0	36.0	33.0	38.0	32.0	31.0
Land purchases, acres	520	480	400	360	240	240	120	0
Year first purchased	3	3	3	4	4	6	8	0
Credit score	10	10	10	10	10	8	8	8
Credit class	2	2	2	2	2	2	2	2
Interest rate	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
III Price response; growth rates: operating costs, 3%; farm income and land values, −1%								
Net worth change, %	12.5	10.4	6.0	−2.2	−20.6	−76.4	−198.6	−355.9
Return on assets, %	0.43	0.19	0.00	−0.28	−0.35	−0.49	−1.46	−1.46
Return on equity, %	−3.03	−3.67	−4.71	−6.54	−14.03	−63.63	−99.00	−99.00
Debt to assets, %	27.0	29.0	33.0	39.0	52.0	88.0	141.0	180.0
Land purchases, acres	160	120	80	40	0	0	0	0
Year first purchased	3	3	3	4	0	0	0	0
Credit score	10	14	14	20	26	30	30	30
Credit class	2	2	2	3	4	4	4	4
Interest rate, %	10.0	10.0	10.0	12.0	14.0	14.0	14.0	14.0

cial capacity had accumulated, aided in some cases by a strengthening in the firm's credit classification.

Concluding Comments

Our goal in this study was to portray a firm's financial performance over time in a fashion that endogenizes farm investment decisions, credit evaluation, and loan pricing based on the credit scoring procedures of agricultural lenders. This modeling framework is expected to yield more valid projections of farmers' financial performance, in light of lenders' increasing use of differential loan pricing as a response to changes in a borrower's credit worthiness. As the results of the growth-oriented simulation analysis show, the adoption of credit-scored pricing yields time patterns of performance, credit classifications, and interest rates that parallel the changes in the firm's financial position arising from its investment, financing, and debt servicing activities. Moreover, including the lenders' price responses in the analysis provides an internal control mechanism that dampens the growth incentive as credit worthiness diminishes, stimulates growth as credit conditions strengthen, and leads to similar capital structures over time, at least under the deterministic conditions of this study.

Extensions of the analysis could compare the effects on farm financial performance of interrelationships between different risk attitudes of borrowers and lenders, as expressed through the credit scoring model, as well as considering the effects of alternatives in risk management for farm businesses with different structural characteristics. Further refinements of the credit scoring mechanism and the pricing intervals also could occur in order to tailor the modeling approach to different farm situations and different types of lenders. In any case, including credit-scored pricing in farm planning models and in loan analysis is an important step that is consistent with the emerging practices of agricultural lenders.

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References

Baker, C. B. "Credit in the Production Organization of the Firm." *Amer. J. Agr. Econ.* 49(1968):507–21.

Barry, P. J., and C. B. Baker. "Reservation Prices on Credit Use: A Measure of Response to Uncertainty." *Amer. J. Agr. Econ.* 53(1971):222–28.

Barry, P. J., and J. D. Calvert. "Loan Pricing and Customer Profitability Analysis by Agricultural Banks." *Agr. Finan. Rev.* 43(1983):21–29.

Barry, P. J., and D. R. Willmann. "A Risk-Programming Analysis of Forward Contracting with Credit Constraints." *Amer. J. Agr. Econ.* 58(1976):62–70.

Barry, P. J., C. B. Baker, and L. R. Sanint. "Farmers' Credit Risks and Liquidity Management." *Amer. J. Agr. Econ.* 63(1981):216–27.

Bieber, David. "Development of a Risk Index for PCA Loans and Loan Portfolio." *Financial Markets for Agriculture: Macro, Institutional and Policy Issues.* Dep. Agr. Econ., University of Illinois, AE-4589, February 1985.

Chhikara, R. K. "Liquidity Management Hypothesis: Theoretical Foundations, Empirical Tests, and Applications." Ph.D. thesis, University of Illinois, 1986.

Dunn, D., and T. L. Frey. "Discriminant Analysis of Loans for Cash Grain Farmers." *Agr. Finan. Rev.* 36(1976):60–66.

Farm Credit Banks of St. Louis, Risk Index, St. Louis, MO, 1986.

Fischer, M. L., and K. Moore. "An Improved Scoring Function for the St. Paul Bank for Cooperatives." *Financing Agriculture in a Changing Environment: Macro, Market, Policy and Management Issues,* Dep. Agribusiness Econ., Southern Illinois University, January 1987.

Hardy, W. E., and J. B. Weed. "Objective Evaluation for Agricultural Lending." *S. J. Agr. Econ.* 12(July 1980): 159–64.

Hayes, D. A. *Bank Lending Policies: Domestic and International.* Graduate School of Business Administration, University of Michigan, 1977.

Lee, W. F., and C. B. Baker. "Agricultural Risks and Lender Behavior." *Risk Management in Agriculture,* ed., P. J. Barry. Ames: Iowa State University Press, 1984.

Lufburrow, J., P. J. Barry, and B. L. Dixon. "Credit Scoring for Farm Loan Pricing." *Agr. Finan. Rev.* 44(1984): 8–14.

Pflueger, B. W., and P. J. Barry. "Crop Insurance and Credit: A Farm Level Simulation Analysis." *Agr. Finan. Rev.* 46(1986):1–14.

Richardson, J. W., and C. J. Nixon. *The Farm Level and Policy Simulation Model: FLIPSIM.* Dep. Tech. Rep. No. 81-2. Texas A&M University, 1981.

Schmiessing, B. H., M. A. Edelman, C. Swinson, and D. Kolmer. "Differential Pricing of Agricultural Loans by Commercial Banks." *West. J. Agr. Econ.* 10(1985): 192–204.

Schnitkey, G. D., P. J. Barry, and P. N. Ellinger. "A Microcomputer Analysis of Farm Financial Performance." *S. J. Agr. Econ.* 19(December 1987):203–8.

Sonka, S. T., B. L. Dixon, and B. L. Jones. "Impact of Farm Financial Structure on the Credit Reserve of the Farm Business." *Amer. J. Agr. Econ.* 62(1980): 565–70.

Stover, R. D., R. K Teas, and R. J. Gardner. "Agricultural Lending Decision: A Multiattribute Analysis." *Amer. J. Agr. Econ.* 67(1985):513–20.

Tongate, Ronald. "Risk Indexing: A Valuable Tool for Today's Lender." *AgriFinance* March 1984, pp. 12–13.

Walker, O. L., and G. A. Helmers. "Applications II: Simulation." *Risk Management in Agriculture,* ed., P. J. Barry. Ames: Iowa State University Press, 1984.