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Migration analysis, a probability-based measurement concept, has been long employed as a routine approach by such companies as Moody's and Standard and Poor's in evaluating changes in the risk rating of bonds and other publicly traded securities. The concept has been more recently used as an analytical framework for developing probability estimates of financial stress and/or default rates for commercial, agricultural and other types of loans (Saunders; Caoutte, Altman, and Narayanan; Barry, Escalante, and Ellinger).

The migration approach entails tracking an individual borrower's historic rates of movement among the lender's credit risk rating classes within a specified time period. These migration rates are then extrapolated to formulate projections of the credit quality of the lender's entire portfolio according to overall trends in class upgrades versus downgrades and derived estimates of probability of loan default or stress rates.

Such migration-based measures of credit risk quality could be used as important inputs in the determination of the regulatory requirements for economic capital held by lenders under the proposed New Basel Accord (Barry). Compared to the traditional measurement of historic loan default rates, the credit risk estimates obtained through the migration approach provide richer, much broader information on the risk stability and quality of a lender's loan portfolio, especially when based on more extensive historical data.

In the area of agricultural lending, a number of lenders, especially Farm Credit System institutions, have already ventured into using the credit migration concept to analyze their loan portfolios, although their data histories tend to be shorter at less than five years in length. In the agricultural finance literature, Barry, Escalante and Ellinger have utilized longitudinal farm-level data to produce estimates of transition probability rates, overall credit portfolio upgrades and downgrades, and financial stress rates over time. Their study demonstrates the practical relevance of the migration framework in the assessment of credit portfolio qualities and its potential appeal to farm lenders still developing their own credit risk measurement frameworks.

This study pursues the application of migration analysis to agricultural loans through a deeper investigation of the uniqueness of credit migration rates for farm borrowers relative to other classes of borrowers. Earlier estimates of farm credit migration rates indicate lower class retention rates and highly volatile transition probabilities compared to results obtained for bonds and other publicly traded securities (Barry, Escalante, and Ellinger; Altman and Kao). This result is consistent with the riskier nature of farming operations that are easily more susceptible to seasonal fluctuations in weather and market conditions than firms belonging to other industries. This study examines linkages between the transition probabilities and factors related to farm structure, business risk and risk-reducing plans employed by farm decision-makers. In the absence of actual farm borrowers' data from lenders, farm-level data from the Illinois Farm Business Farm Management (FBFM) system for the period 1995-2000 are instead used in this analysis.

The following sections explain the mechanics of the migration model, discuss the development of the empirical framework and present the results of the descriptive and econometric analyses.

Deriving Transition Probabilities (Migration Rates)

To illustrate migration rates, consider a simplified loan rating system with two credit risk classes, A and B, signifying low and high risk, respectively. An A-rated loan can either remain in class A or migrate to class B in the next period. Similarly, a B-rated loan can either remain in class B or migrate to class A. These possibilities are portrayed in Figure 1. The transition probabilities (P_i values) are estimated from historic migration rates. For example, historic rates of movements among classes might indicate that class A loans remain in class A 90% of the time and migrate to class B 10% of the time. Class B loans remain in class B 85% of the time and migrate to class A 15% of the time.

The transition probability matrix in Figure 2 then expresses the combined migration patterns. In this case, potential upgrading (downgrading) of a loan is represented by arrow BA (AB), and arrows AA and BB represent the stationary class ratings. The aggregate rate of high risk (i.e., being in Class B) would be the weighted average of AB and BB using the relative numbers or volumes of loans A and B as the weights. Continuing the numerical example, if classes A and B comprise 75% and 25%, respectively, of the portfolio, then the weighted average of class B is 28.75% - - .2875 = (.10)(.75) + (.85)(.25).

These rating migrations may be measured for any length period, although one year is the most common (Saunders; Crouhy, Galai, and Mark). Generally, probabilities for interclass migrations tend to increase as the length of period increases, reflecting the potential for greater fluctuations in economic conditions over longer periods (Carty and Fons). The migration rates may also differ across industries (e.g., Moody's).

Data and Measurement Issues

There are two important considerations in the application of credit migration analysis: the choice(s) of classification variable and the type(s) of migration measurement approaches. Several options for the classification variable include measures of profitability (return on equity), repayment capacity and the credit score, which is a composite index of credit risk that usually includes the prior measures and other financial factors.

In this study, a farm's credit score is used to assign farmers into different credit risk classes. This will be determined through a uniform credit-scoring model for term loans reported by Splett et al. that is based on financial ratios recommended by the Farm Financial Standards Council representing a farm's solvency, repayment capacity, profitability, liquidity and financial efficiency. This study will follow the measurement procedures, the pre-determined weights assigned to each component of the credit-scoring model and classification intervals used by Splett, et al. These details are reported in Table 1.

Outlier values for the current ratio and the repayment capacity measures will be replaced by maximum values used by Barry, Escalante and Ellinger, i.e., current ratios exceeding the value of 7 were assigned the maximum value of 7 while the equivalent bounds (-1.25 to 0.93) for the repayment capacity measure suggested by Novak and LaDue were used in this study.

The classification criterion, a farm's credit score, will be evaluated using various measurement approaches, involving different sample sizes and time sequences of data employed in the measurement process. This study will use the following two of four measurement

approaches presented in the earlier study by Barry, Escalante and Ellinger that resulted in relatively greater volatility of credit migration rates:

1. Year-to-Year Transition (1 x 1)
   This measures movements in credit risk ratings given in a particular year (n) to those assigned to the borrower in the succeeding year (n + 1).
2. Three-Year Average to Fourth Year (3 x 1)
   This measures the transition from a credit score rating based on the average of the first three years to the risk rating given to the borrower on the fourth year.

This study utilizes annual data from farms that maintained certified usable financial and family living records under the Illinois FBFM system during the period 1995 to 2000. The FBFM system has an annual membership of about 7,000 farmers but rigorous certification procedures implemented by field staff usually results in much fewer farms with both certified financial and family living records. Over the sample six-year period, five (5) year-to-year transition matrices were developed using only the common farms present in two consecutive time periods. The sizes of these bi-annual sub-data sets ranged from 703 to 1,111 farms. On the other hand, the 3 x 1 transition matrices were developed from common farms with consistently acceptable farms records for any four consecutive years. Three matrices were constructed using this measurement approach involving 474, 565 and 610 farms for the 1995-1998, 1996-1999 and 1997-2000 sub-data sets, respectively.

The Transition Probability Matrices

The average one-period transition matrices for the year-to-year (1 x 1) and three-year average-to-fourth year (3 x 1) measurement approaches are reported in Table 2. Generally, the class retention rates obtained in this study are lower than those reported by Barry, Escalante and Ellinger. For instance, under the 1 x 1 approach, the retention rate for class 1 is only 68.09% compared to 75.26% rate obtained in the earlier study for the same class rating. An almost similar gap in Class 1 retention rates is noted under the 3 x 1 approach where this study's result of 71.29% falls below the earlier result of 77.18%.

Greater disparity of values is noted when current and past results for Class 5 retention rates are compared. Specifically, class 5 retention rates of 20.08% and 20.74% obtained here for the 1 x 1 and 3 x 1 approaches, respectively, are about 12 to 15 percentage points lower than the results of the earlier study.

The overall trends of retention, upgrading and downgrading are reported in Table 3 for both measurement approaches. As expected, the average retention rates are much lower than those calculated for corporate loans, bonds and other publicly traded securities. In their analysis of one-year rating migrations for bonds and corporate loans, Altman and Kao report retention rates ranging from 86.1% to 100%, while Carty and Fons report retention rates ranging from 75.7% and 89.6%. This study reports an average retention rate of about 45%.

Moreover, studies on bond migration normally reflect a general tendency toward more downgrading than upgrading of class ratings. Even the results reported by Barry, Escalante and Ellinger follow the same pattern for some measurement approaches. In contrast, this study's results reflect a more dominant trend in class upgrades than downgrades.

Differences in time frames and length considered in this study and the previous work of Barry, Escalante and Ellinger could account for these trends in the migration results. This study utilizes a shorter time frame from 1995 to 2000 that covers most of the implementation period of

the 1996 farm bill. The bill introduced major changes in federal policy towards agriculture that include its "freedom to farm" provision and the shift from market-based to fixed, decoupled production and price support payments. The impacts of these institutional changes have been aggravated by downturns in commodity prices coinciding with the early years of the transition period. These downward price trends are believed to have resulted from high production and large carry-over stocks due to the bill's "freedom to farm" attribute.

Surprisingly, farm borrowers have been able to maintain better repayment records than borrowers from other industries despite the farms' lower revenues generated during this period (Federal Reserve Bank of Chicago; Escalante). Improvements in farm debt repayment capacity were largely attributed to substantial cash receipts from unexpected ad hoc federal subsidies, off-farm employment and investments, and, in some parts of the country, revenues from sale of non-traditional or auxiliary farm products and services (BEA; USDA; Escalante).

The previous study, on the other hand, had a longer time frame extending from 1985 to 1998. The absence of reliable income safety nets and effective liquidity-enhancing strategies during the "farm financial crises" of the eighties resulted in the deterioration of the farmers' debt repayment capacity. The greater incidence of farm failures and loan defaults experienced during this period could have significantly influenced a more dominant trend of downgrading versus upgrading of credit rating classes.

Econometric Model for Credit Rating Migration

The probability that a credit upgrade (UpGrd) occurred is specified as a nonlinear (logit) function of farmer demographic variables and financial characteristics of the farm business. Time-series measures on the state of the economy along with regional measures such as agronomic, climatic, or production conditions where the farm business is located can also be included in the vector of explanatory variables. Let UpGrd represent a dichotomous variable where d = 1 if an upgrade took place and d = 0 if a downgrade occurred. A model for a binary dependent variable which takes on the values zero or one is appropriate so that:

$$(1) \qquad Y = \log it(p) = \log\left(\frac{p}{1-p}\right) = a + BX + e$$

where Y is the event of interest that takes on an ordered value of 1 if the event happens and 0 if otherwise; p is the probability of the occurrence of the event, i.e., P(Y=1); while a, B, X and e correspond to the model intercept, the coefficient estimate(s), the explanatory variable(s) and the error term, respectively, which are the usual components of right-hand side of an estimating equation. The objective is to define a model for the right-hand side of the equation. Greene (2000) notes that any proper, continuous probability distribution defined over the real line is appropriate for specifying the model. The probability that an upgraded credit rating is obtained relative to a downgrade is specified as a nonlinear (logit) function of demographic variables, farm characteristics, and time period effects.

The Explanatory Variables

The preliminary version of the estimating equation involves nine (9) independent variables representing certain structural and demographic characteristics of the farm, in addition to proxy measures for risk and risk-management strategies employed by farmers. The equation

will be subsequently expanded in a later version of this study to include effects of time period, social capital and macroeconomic factors.

This study considers the effects of the following factors on the likelihood of an improvement in credit risk rating for the farm:

> *Structural and Demographic Factors*. Farm size (measured in gross revenues), the operator's age, the farm's tenure position, and productivity of soil and farm assets could significantly affect the resiliency and financial performance of the farm business. Larger farms are usually able to achieve improved production efficiencies under economies of scale. These benefits, however, could be tempered by leverage decisions that are non-optimal, create greater financial stress for the farm business and decrease the probability of an upgrading of the farm's credit risk rating. The same result applies to older farmers, who tend to be more risk averse (Patrick, Whitaker and Blake; Lins, Gabriel and Sonka) and implement more cautious business plans that do not always realize the full growth potential of their farm businesses. Moreover, higher tenure ratios (greater proportions of owned to total farmland acreage) are usually associated with lower accounting rates of return (Ellinger and Barry), thus, could potentially affect upward migration into higher credit rating classes. On the other hand, higher levels of soil and farm asset productivity (represented here by the asset turnover ratio) could result in better profitability and financial efficiency measures that increase the probability of an improvement in the farm's credit risk classification.
> *Risk*. Measures of coefficients of variation (CV) are calculated for net farm and off-farm incomes, the two major sources of repayment funds. Greater stability of returns from farm and non-farm sources enables farmers to devise effective business plans that anticipate adjustments in the farm's liquidity and profitability conditions. Ultimately, better financial performance of the farm business results in greater likelihood of improvements in credit risk ratings.
> *Risk Management Strategies*. Substantial reductions in risk realized through enterprise diversification (measured using the Herfindahl measure of concentration) and greater reliance on share versus cash leasing contracts could influence the likelihood of upward credit risk migration trends. The overall influence of the diversification strategy on this model's dependent variable, however, depends on tradeoffs between risk reduction (resulting from the diversification strategy) and high revenue potentials (through comparative trade advantages enjoyed by specialized grain farming operations in North Central Illinois (Barry, Escalante and Bard)). Share leasing is considered the most highly risk efficient financing option for farmers (Barry, et al.). The positive correlation between the value of harvested crops and the tenant farmer's rental obligation to the landowner stabilizes the farmer's net income, thus resulting in greater risk-reducing benefits for the farm operator.

Econometric Results

Maximum likelihood estimates for selected binary logistic models of credit risk migration are presented in Table 4. The impacts of key explanatory variables on the probability that a farm business has an upgrade relative to a downgrade in its risk rating are presented in Table 4 along with standard errors for these measures. The binary logistic model is used to evaluate the impact of a change in any continuous explanatory variable on the probability of an upgrade.

Along with the binomial logistic procedures, a backward elimination procedure (using a 20% confidence limit) was further applied to each model to eliminate variables that had the least significant contributions to the model's explanatory power.

Results for two of the five possible 1 x 1 models are reported in Table 4. These two bi-annual models (for 1996-1997 and 1997-1998) produced stronger and more intuitive results than those obtained for the other three models. Their results suggest the importance of risk reduction in increasing the probability of an upgrade in the farm's credit risk classification. Specifically, the net farm and off-farm income variables had negative, significant coefficient estimates.

These results are reinforced by the significance of variables representing certain risk management strategies employed by farmers. The enterprise diversification index is consistently negatively signed and significant in both models, thus, suggesting that greater diversification among crop, livestock and auxiliary farm products (since lower index values indicate higher levels of diversification) would increase the likelihood of improvements in the farm's credit risk rating. Moreover, the results also suggest that greater reliance on share (versus cash) leasing is also directly related to higher probabilities of credit rating upgrades.

Smaller farms, with their more dynamic and flexible business operations, also tend to have greater tendencies to move up the credit risk rating scale. The same condition applies to farms with lower asset productivity ratios, which could have resulted from larger asset complements required to further diversify farm enterprise mix.

In the case of the 3 x 1 transition approach, instead of breaking down the data set into three smaller data subsets, a single regression procedure was applied to the entire group of farm observations. Also, two time dummy variables were added to the estimating equation. The results indicate the importance of farm size and the time dummy variable for 1997-2000 in explaining increases in probability of class upgrades. The share lease ratio variable is also significant but not properly signed.

The logit model for the 3 x 1 transition approach correctly predicted 79% of the 435 upgrades that occurred and 38% of the 318 downgrades with an overall correct prediction value of 62%. Incorrect predictions can be allocated between two situations that may be evaluated with different adverse consequences by the credit scoring agency. When the model predicts an upgrade will occur when a downgrade actually took place (an overprediction), the model suggests that the farm business is a good credit risk when in fact the farm business is not. Overpredictions occurred in 62% of the actual downgrade cases.

Concluding Remarks

This preliminary study has produced some interesting implications on the potential importance of minimizing business risk in increasing the probability of upgrading a farm's credit rating class. This result is enhanced in this study through the significance of such risk reduction strategies as share leasing and enterprise diversification. Initial results also suggest that smaller farms are more dynamic and implement more aggressive business plans that increase their upward mobility in the credit rating scale.

It remains to be seen, however, if these variables will retain their significance in an expanded model that considers a longer time-series of farm data extending back to the early eighties. The more complete model will also try to accommodate measures that capture the social

capital endowment of the locality where the farms are situated as well as macroeconomic factors and financial variables that could serve as better proxies to the credit score components.

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Table 1. Credit Scoring, Profitability and Repayment Classification Intervals (Source: Splett et al.)

VARIABLES (Measures)/Classes	*Interval Ranges*	*Weights*
LIQUIDITY (Current Ratio)		
1	>2.00	
2	1.60-2.00	
3	1.25-1.60	
4	1.00-1.25	
5	<1.00	_____ x 0.10 = _____
SOLVENCY (Equity-Asset Ratio)		
1	>0.80	
2	0.70-0.80	
3	0.60-0.70	
4	0.50-0.60	_____ x 0.35 = _____
5	<0.50	
PROFITABILITY (Farm Return on Equity)		
1	>0.10	
2	0.06-0.08	
3	0.04-0.06	
4	0.01-0.04	
5	<0.01	_____ x 0.10 = _____
REPAYMENT CAPACITY (Capital Debt-Repayment Margin Ratio)*		
1	>0.75	
2	0.50-0.75	
3	0.25-0.50	
4	0.05-0.25	_____ x 0.35 = _____
5	<0.05	
FINANCIAL EFFICIENCY (Net Farm Income from Operations Ratio)		
1	>0.40	
2	0.30-0.40	
3	0.20-0.30	
4	0.10-0.20	
5	<0.10	_____ x 0.10 = _____
	= TOTAL SCORE (Numeric)	_____
CREDIT SCORE CLASSES		
Class 1		1.00-1.80
Class 2		1.81-2.70
Class 3		2.71-3.60
Class 4		3.61-4.50
Class 5		4.51-5.00

Note: * New interval ranges for the repayment capacity measure were used in this study since the intervals proposed by Splett, *et al.* resulted in the heavy concentration of observations in the first class.

Table 2. Average One Period Transition Matrices for Credit Scores, 1995-2000					
Period 1 Classes	Period 2 Classes				
	1	2	3	4	5
Year-to-Year Transition (%)					
1	68.09	21.96	9.06	0.81	0.08
2	22.05	39.85	29.78	7.66	0.66
3	8.58	24.82	42.67	19.55	4.38
4	2.35	18.15	43.54	27.04	8.93
5	0.00	2.89	49.18	27.85	20.08
Three Year average to Fourth Year Transition (%)					
1	71.29	20.38	7.47	0.86	0.00
2	27.77	40.35	26.86	4.36	0.66
3	7.84	26.19	42.89	18.53	4.54
4	1.20	14.09	48.44	27.53	8.74
5	0.00	0.00	52.82	26.44	20.74

Table 3. Summary Transition Rates for Illinois Farms, 1995-2000	
Time Sequence	Percent of Farms (No. of Farms)
Retention	
Year-to-Year Transition	44.9 (2,153)
Three Year Average to 4th Year Transition	44.2 (728)
Upgrades	
Year-to-Year Transition	28.9 (1,386)
Three Year Average to 4th Year Transition	32.6 (537)
Downgrades	
Year-to-Year Transition	26.2 (1,254)
Three Year Average to 4th Year Transition	23.3 (384)

Table 4. Results of Selected Binomial Logistic Regression Models Dependent Variable: Y=1 for Upgrades, Y=0 for Downgrades		
Year/Remaining Variables	Coefficient Estimate	Standard Error
1996-1997 (1 x 1 Transition)		
Intercept	0.9649	0.6299
Share Lease Ratio	0.5895**	0.2847
Farm Size	1.186E-6	8.227E-7
Enterp. Diversif. Index	-0.9873	0.6530
Net Farm Income Risk	0.0576	0.0440
Off-farm Income Risk	-0.2481**	0.1070
Likelihood Ratio	18.2740***	
% Correct Predictions	59.4	
1997-1998 (1 x 1 Transition)		
Intercept	-1.6700	1.9636
Asset Turnover Ratio	-0.4254*	0.2302
Farm Size	-1.96E-6**	8.039E-7
Enterp. Diversif. Index	-1.0382*	0.5793
Net Farm Income Risk	-0.0450*	0.0240
Age	0.1320*	0.0814
Age^2	-0.0014*	0.0008
Likelihood Ratio	24.8862***	
% Correct Predictions	62.9	
All Years (3 x 1 Transition)		
Intercept	.07889	0.4477
Tenure Ratio	0.1622	0.4422
Share Lease Ratio	-0.3850*	0.2318
Asset Turnover Ratio	-0.4167	0.0829
Farm Size	-0.1546***	0.0061
Dummy for 1996-1999	0.2966	0.1864
Dummy for 1997-2000	0.9392***	0.1908
Age	0.8272	0.0079
Likelihood Ratio	-494.6303***	
% Correct Predictions	61.6	

Note: Asterisks denote significance at 90%(*), 95%(**) and 99%(***) levels.

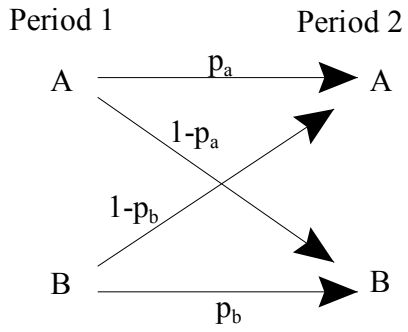

Figure 1. Migration Alternatives and Probabilities

Period 1 \ Period 2	A	B
A	90%	10%
B	15%	85%

Figure 2. Transition Probability Matrix