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Credit Risk Migration Analysis of Cooperatives

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Introduction



Credit Migration Analysis

- Categorize a cooperative's credit risk by a rating
- Over time, a cooperative may "migrate" or "transition" from one rating to another or remain unchanged
- Probabilities can be assigned representing the likelihood of transition from one state to another or remaining unchanged by observing historical data to create a *"transition matrix"*
- Furthermore, predictions about future states (n periods) of a cooperative given their current rating can be made by using the transition matrix



Methodology

Moody's Credit Rating Methodology & Markov Chains



Moody's Credit Rating Methodology

Global Agricultural Cooperatives Industry

• Moody's assesses 4 qualitative and quantitative broad Rating Factors :

- 1. Scale and Diversification (subjective)
- 2. Franchise Strength (subjective) and Growth Potential (subjective)
- 3. Financial Flexibility (subjective)
- 4. Financial Strategy (subjective) and Credit Metrics (objective)
- Each broad factor is comprised of sub-factors
- Sub-factors are rated and scored
- A weight is assigned to its corresponding sub-factor
- The *"Indicated Rating"* is the summation of the product of each sub-factor score by its respective weight



Moody's Credit Rating Methodology

Identification of Key Rating Factors

RATING FACTORS	SUB-FACTORS	WEIGHTING	CUMULATIVE SUB- FACTOR WEIGHTING
1 Scale and	a) Total Sales (USD Billion)	5.00%	
Diversification -	b) Geographic Diversification – Sales Sales Concentration to a Single Market Region And Sales to Developed Market Regions	5.00%	25.00%
-	c) Geographic Diversification – Raw Materials Supply Concentration from a Single Producing Region	5.00%	23.0070
_	d) Segmental Diversification	10.00%	
2 Franchise Strength	a) Market Share	5.00%	
and Growth Potential	b) Organic Volume Growth	5.00%	20.00%
_	c) Qualitative Assessment of Portfolio	10.00%	
3 Financial Flexibility	a) Willingness and Ability to Reduce Member Payments; Relative Size of Member Payments	10.00%	10.00%
4 Financial Strategy	a) Financial Strategy	5.00%	
and Credit Metrics	b) Debt / Coop EBITDA	10.00%	
	c) Coop RCF / Net Debt	10.00%	45.00%
	d) Coop EBITA / Interest Expense	10.00%	
	e) (Coop RCF-Capex) / Debt	10.00%	
Tatal		100.00%	100.00%



Moody's Credit Rating Methodology

Determining the Overall Grid-Indicated Rating

- Each Sub-Factor's calculated value is mapped to a Sub-Factor Rating
- The Sub-Factor Rating is then mapped to a Sub-Factor Score
- The 4 Sub-Factor Scores are multiplied by an equal weight and summed to obtain the Aggregate Weighted Factor Score
- Lastly, the Aggregate Weighted Factor Score is mapped to the Indicated Rating

Sub-Factor Mapping/Sco	oring						
Measurement Outcome	Strongest <	<				> '	Weakest
Sub-Factor Rating	Aaa	Aa	А	Baa	Ba	В	Caa
Sub-Factor Score	1	3	6	9	12	15	18

Source: MOODY'S INVESTOR SERVICE

INDICATED RATING	AGGREGATE WEIGHTED FACTOR SCORE RANGE						
Aaa			x	<	1.5		
Aa1	1.5	≤	x	<	2.5		
Aa2	2.5	≤	x	<	3.5		
Aa3	3.5	≤	x	<	4.5		
A1	4.5	≤	x	<	5.5		
A2	5.5	≤	x	<	6.5		
A3	6.5	≤	x	<	7.5		
Baa1	7.5	≤	x	<	8.5		
Baa2	8.5	≤	x	<	9.5		
Baa3	9.5	≤	x	<	10.5		
Ba1	10.5	≤	х	<	11.5		
Ba2	11.5	≤	x	<	12.5		
Ba3	12.5	≤	х	<	13.5		
B1	13.5	≤	х	<	14.5		
B2	14.5	≤	х	<	15.5		
B3	15.5	≤	x	<	16.5		
Caa1	16.5	≤	x	<	17.5		
Caa2	17.5	≤	х				

Source: MOODY'S INVESTOR SERVICE



Markov Chain Theory

• A First-Order Markov Chain is a discrete-time stochastic process $\{X_n\}_{n \in \mathbb{N}_0}$ with a *Markov Property* that takes on values in a countable state space *S* if,

 $\mathbb{P}[X(t) = i | X(t-1) = j, X(t-2) = i_{t-2}, \dots, X(0) = i_0] = \mathbb{P}[X(t) = i | X(t-1) = j],$ for all $n \in \mathbb{N}_0$, and all $i \in S$

- The Markov Property requires no autocorrelation (memoryless)
- The likelihood of a step from state *i* to state *j* is called the *transition probability* denoted as p_{ij}
- p_{ij} must be independent of states prior to t 1 i.e. *Time-Independence*
- When p_{ij} does not change across time i.e. the stochastic process is *Time-Homogenous*
- Nickell et al. (2000), Bangia et al. (2002), and Rachev and Trueck (2009) argue credit rating transition probabilities vary with the business cycle



Data and Results

Data provided by CoBank



Distribution of Co-ops by Location 155 Co-ops, 22 States





Distribution of Credit Ratings



Agricultural Economics

R S ITY

Notable Periods

- 1996 2001: A relatively quiet period. Some profitability, not much growth, pretty steady from a financial perspective.
- 2002 2004: Financial stress as a result of the Farmland Industries bankruptcy. *"Early 2000s Recession"* possibly contributing to the stress during this period.
- 2005 2007: A relatively quiet period. Some profitability, not much growth, pretty steady from a financial perspective.
- 2008 2009: Large runup in grain prices. Commodity markets experienced extreme volatility due to the *"Great Recession"* and Financial Crisis.
- 2010 2014: Boom times for cooperatives. Cooperatives attaining large profits. Cooperatives are growing organically and via mergers. Increased leverage.



How Have Ratings Transitioned Over Time?



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MLE One-Period Transition Matrix, 1996 - 2014

Assuming the Markov Chain is Time-Homogenous and Time-Independent

• Following Anderson and Goodman (1957), and Basawa and Prakasa Rao (1980), the MLE of p_{ij} results in \hat{p}_{ij}

	Period 2 Generic Ratings					
Period 1 Generic Ratings	Aa	А	Baa	Ba	В	Caa
Aa	0.09	0.24	0.24	0.26	0.15	0.03
Α	0.04	0.23	0.30	0.30	0.07	0.06
\mathbf{Baa}	0.02	0.08	0.32	0.25	0.25	0.08
Ba	0.01	0.03	0.15	0.31	0.31	0.18
В	0.01	0.01	0.06	0.17	0.43	0.32
\mathbf{Caa}	0.00	0.01	0.02	0.08	0.30	0.59



The Steady State

Converging Towards the Limiting Distribution

Given an initial distribution h(0), Distribution after 1 period: $h(1) = h(0) * \Pi^1$ Distribution after m periods: $h(m) = h(0) * \Pi^m$ Distribution converges toward the limiting distribution h^* as m gets large $h^* = \lim_{m \to \infty} h(0) * \Pi^m$

	Period 2 Generic Ratings					
Period 1 Generic Ratings	Aa	Α	Baa	Ba	В	Caa
Aa	0.01	0.03	0.09	0.18	0.33	0.36
A	0.01	0.03	0.09	0.18	0.33	0.36
Baa	0.01	0.03	0.09	0.18	0.33	0.36
Ba	0.01	0.03	0.09	0.18	0.33	0.36
В	0.01	0.03	0.09	0.18	0.33	0.36
\mathbf{Caa}	0.01	0.03	0.09	0.18	0.33	0.36



Is the System Markovian?

- According to Bickenbach and Bode (2001) the reliability of MLE transition probabilities depend on:
- 1. The system must be Markovian
 - i. Time-Homogenous
 - ii. Time-Independent
- 2. Reliable estimates require a large amount of observations



Detecting Time-Inhomogeneity L2 Norm (Euclidean Distance)

• L2 Norm values are the average root-mean square differences between each One-Period Matrix and the MLE Transition Matrix: $\sqrt{\sum_{n=1}^{N} \sum_{n=1}^{N} (P_{n+1} - P_{n+1})^2}$



Test for Time-Homogeneity

Are the transition probabilities of the Markov Chain constant over time?

- Divide sample into T sub-periods
- $H_0: \forall t: p_{ij}(t) = p_{ij}, where (i, j = 1, ..., N) and (t = 1, ..., T)$
- $H_A: \exists t: p_{ij}(t) \neq p_{ij}$
- Chi-Square Test:

$$Q^{(T)} = \sum_{t=1}^{T} \sum_{i=1}^{N} \sum_{j \in B_{i}} n_{i}(t) \frac{(\hat{p}_{ij}(t) - \hat{p}_{ij})}{\hat{p}_{ij}} \sim asymptotically \chi^{2}(\sum_{i=1}^{N} (a_{i} - 1)(b_{i} - 1))$$

- Results:
 - 2 sub-samples: Chi-Squared Test Statistic = 43.3378, df = 30, p-value = 0.05469399, Fail to Reject Null
 - 3 sub-samples: Chi-Squared Test Statistic = 152.2974 , df = 60, p-value = 0.000000005670535, Reject Null
- Implication:
 - Presence of regime switching. Transition probabilities are not constant over time.



Test for Time-Independence

Are the transition periods independent of states in periods prior to time t - 1?

- According to Tan and Yilmanz (2002) to test the order of a Markov Chain, test order 0 (null) against order 1 (alternative) and if we reject the null, increase order by 1 and test order 1 (null) against order 2 (alternative), repeating the process until we fail to reject a null.
- Chi-Squared Test Order 0 against Order 1:
 - $H_0: \forall i: p_{ij} = p_j$, where (i = 1, ..., N)
 - $H_A: \exists i: p_{ij} \neq p_j$
- Results:
 - Chi-Squared Test Statistic= 565.4265, df = 25, p-value = 0.0000000005670535, Reject Null
- Chi-Squared Test Order 1 against Order 2:
 - $H_0: \forall h: p_{hij} = p_{ij}, where (h = 1, ..., N)$
 - $H_A: \exists h: p_{hij} \neq p_{ij}$
- Results:
 - Chi-Squared Test Statistic= 304.3935, df = 150, p-value = 0.00000000001460389, Reject Null
- Implication:
 - Our stochastic process is of a higher order



Conclusion

• Our Estimated Transition Probabilities are Time-Inhomogeneous

- Time-Inhomogenous for the entire sample
- Time-Inhomogenous during Recessions & Expansions

• The system has memory, higher than 1st – Order

• The value of our research:

- Credit Migration Behavior illustrates the value of the relationship between Co-ops and Lenders
- Co-op Managers and Lenders are able to observe the behavior of Co-ops over 18 years by factoring in exogenous factors such as recessions, and periods of volatile commodity prices
- We can gauge the likelihood of a co-op's credit migration by co-op activity, size, geographic location
- Can be extended by substituting the methodology with a financial metric of interest

• Next Steps:

- We will attempt to determine the order of the stochastic process, 3^{rd} Order : 10^{th} Order
- Instead of splitting time periods into Recessions and Expansions, split into Average Profit and Excellent Profit



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Appendix



Recession Transition Matrix

	Period 2 Short Ratings					
Period 1 Short Ratings	Aa	Α	Baa	Ba	В	Caa
Aa	0.12	0.12	0.25	0.50	0.00	0.00
А	0.07	0.21	0.07	0.50	0.07	0.07
Baa	0.00	0.08	0.49	0.28	0.10	0.05
\mathbf{Ba}	0.03	0.03	0.18	0.31	0.28	0.16
В	0.04	0.04	0.06	0.22	0.37	0.28
Caa	0.02	0.03	0.03	0.13	0.43	0.37



Expansion Transition Matrix

	Period 2 Short Ratings					
Period 1 Short Ratings	Aa	Α	Baa	Ba	В	Caa
Aa	0.08	0.27	0.23	0.19	0.19	0.04
Α	0.04	0.24	0.34	0.26	0.07	0.05
Baa	0.02	0.08	0.29	0.24	0.28	0.09
\mathbf{Ba}	0.00	0.03	0.15	0.31	0.31	0.18
В	0.00	0.01	0.06	0.16	0.44	0.33
Caa	0.00	0.00	0.02	0.07	0.26	0.64



Debt to Co-op EBITDA

The Inverse of the ratio to account for outliers



RS

ITY

Co-op Retained Cash Flow to Net Debt



RS

VE

ITY

Co-op RCF Less CapEx to Debt



