# Credit Risk Migration Analysis of Cooperatives

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Kansas State University | Agricultural Economics

# 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



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# 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 Diversification | a) Total Sales (USD Billion) | 5.00% | |
| | | 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% | |
| | | d) Segmental Diversification | 10.00% | |
| 2 | Franchise Strength and Growth Potential | a) Market Share | 5.00% | |
| | | 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 and Credit Metrics | a) Financial Strategy | 5.00% | |
| | | b) Debt / Coop EBITDA | 10.00% | 45.00% |
| | | c) Coop RCF / Net Debt | 10.00% | |
| | | d) Coop EBITA / Interest Expense | 10.00% | |
| | | e) (Coop RCF-Capex) / Debt | 10.00% | |
| | **Total** | | **100.00%** | **100.00%** |

Source: MOODY'S INVESTOR SERVICE

# 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/Scoring**

| Measurement Outcome | Strongest <---------- | | | | | | > Weakest |
|---|---|---|---|---|---|---|---|
| Sub-Factor Rating | Aaa | Aa | A | Baa | Ba | B | 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 | $1.5 \leq x < 2.5$ |
| Aa2 | $2.5 \leq x < 3.5$ |
| Aa3 | $3.5 \leq x < 4.5$ |
| A1 | $4.5 \leq x < 5.5$ |
| A2 | $5.5 \leq x < 6.5$ |
| A3 | $6.5 \leq x < 7.5$ |
| Baa1 | $7.5 \leq x < 8.5$ |
| Baa2 | $8.5 \leq x < 9.5$ |
| Baa3 | $9.5 \leq x < 10.5$ |
| Ba1 | $10.5 \leq x < 11.5$ |
| Ba2 | $11.5 \leq x < 12.5$ |
| Ba3 | $12.5 \leq x < 13.5$ |
| B1 | $13.5 \leq x < 14.5$ |
| B2 | $14.5 \leq x < 15.5$ |
| B3 | $15.5 \leq x < 16.5$ |
| Caa1 | $16.5 \leq x < 17.5$ |
| Caa2 | $17.5 \leq x$ |

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 $i \in S$

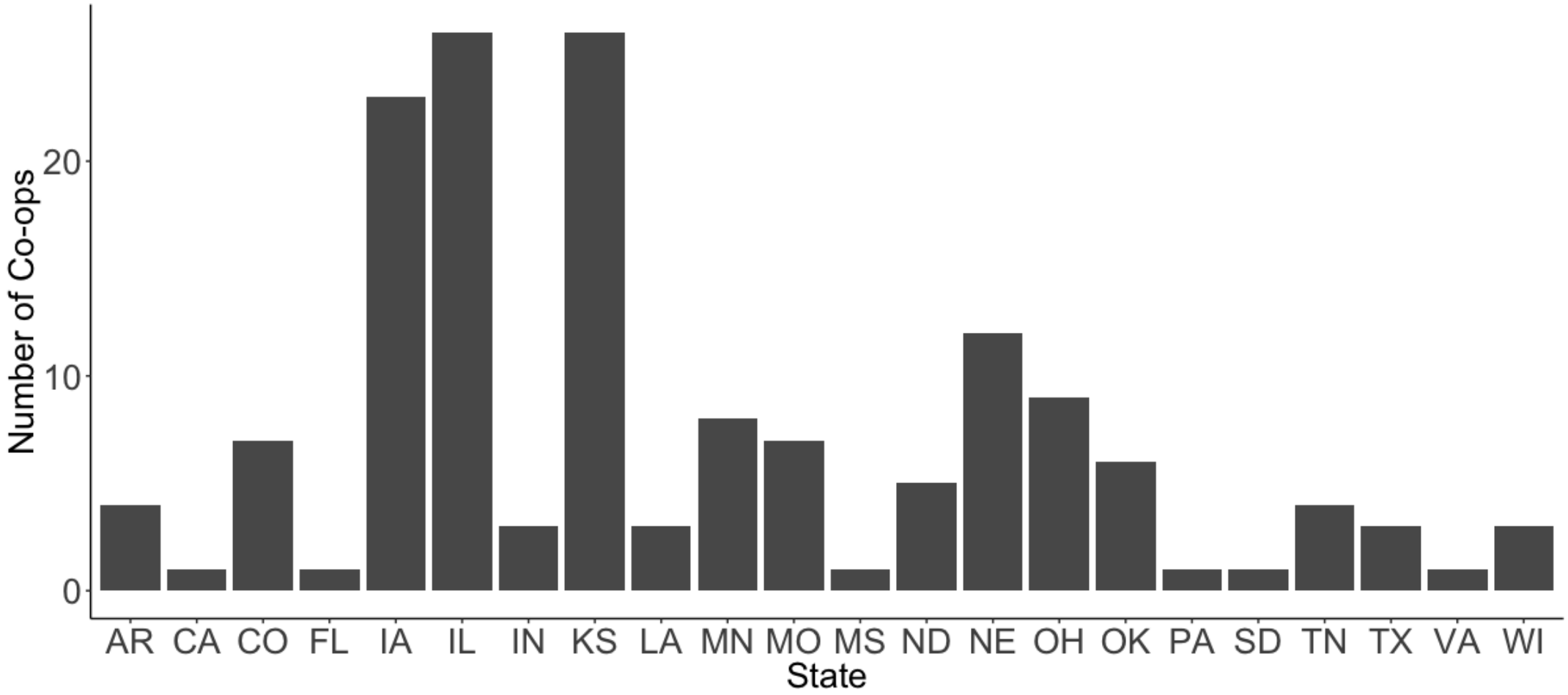
- The Markov Property requires no autocorrelation (*memoryless)*
- The likelihood of a step from state $i$ to state $j$ is called the *transition probability* denoted as $p_{ij}$
- $p_{ij}$ must be independent of states prior to $t-1$ i.e. *Time-Independence*
- When $p_{ij}$ does not change across time 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

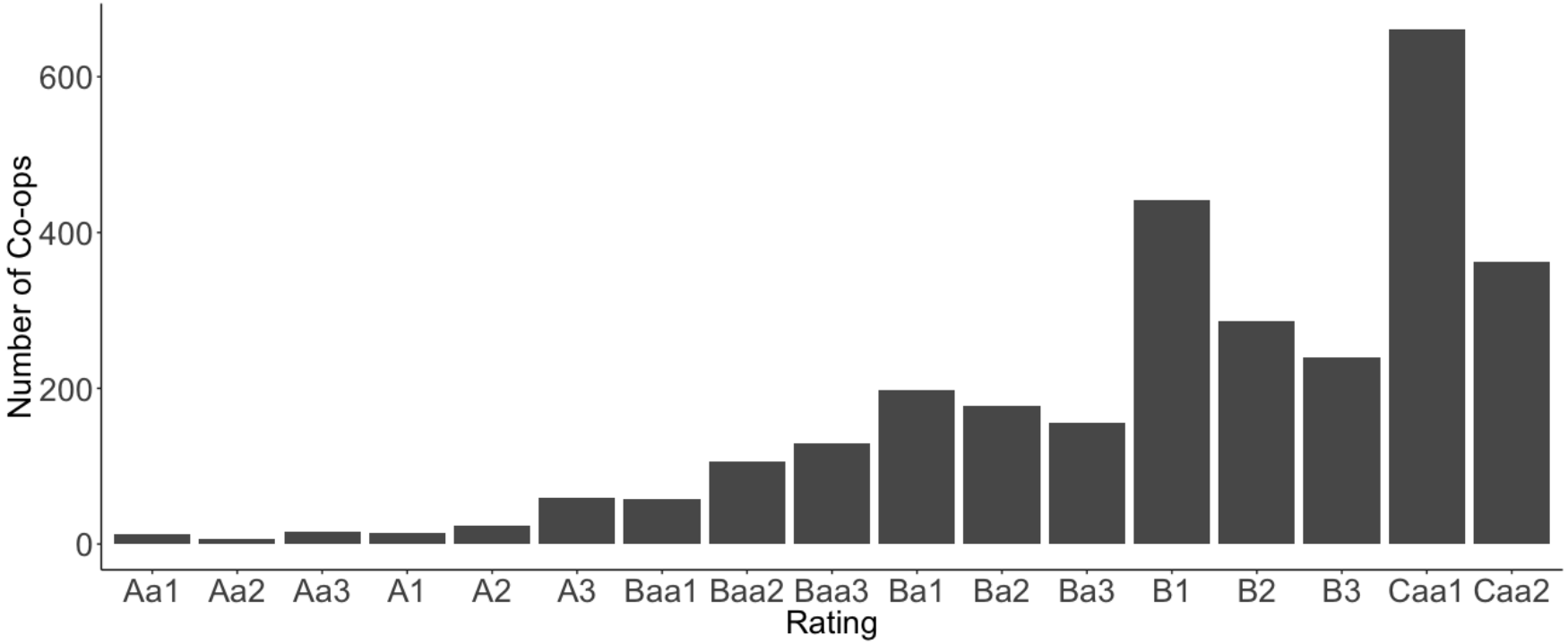
# Distribution of Co-ops by Location

## 155 Co-ops, 22 States

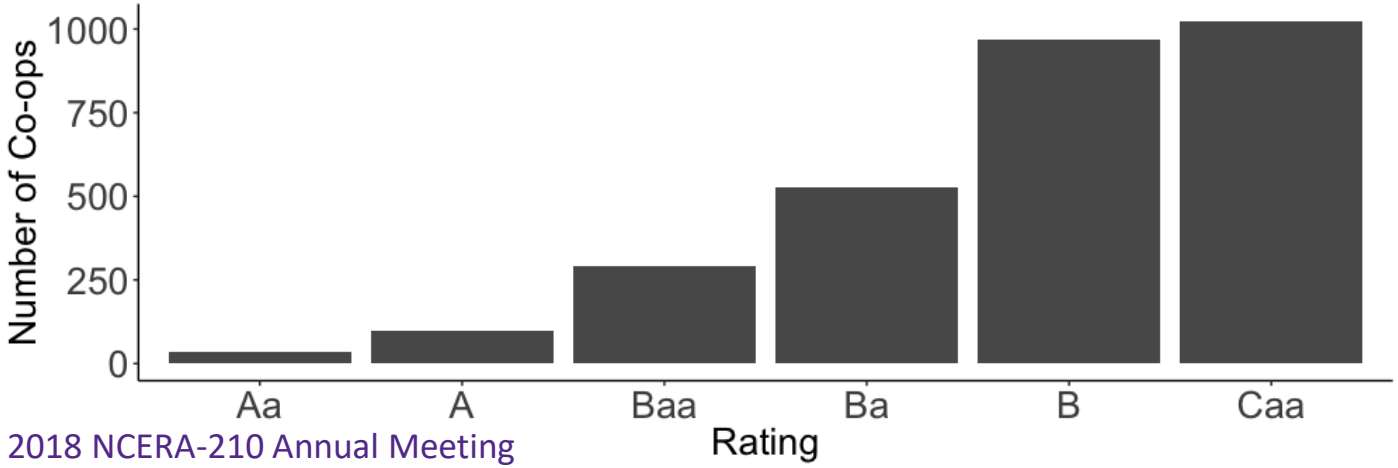



Sources: CoBank

# Distribution of Credit Ratings




Sources: CoBank

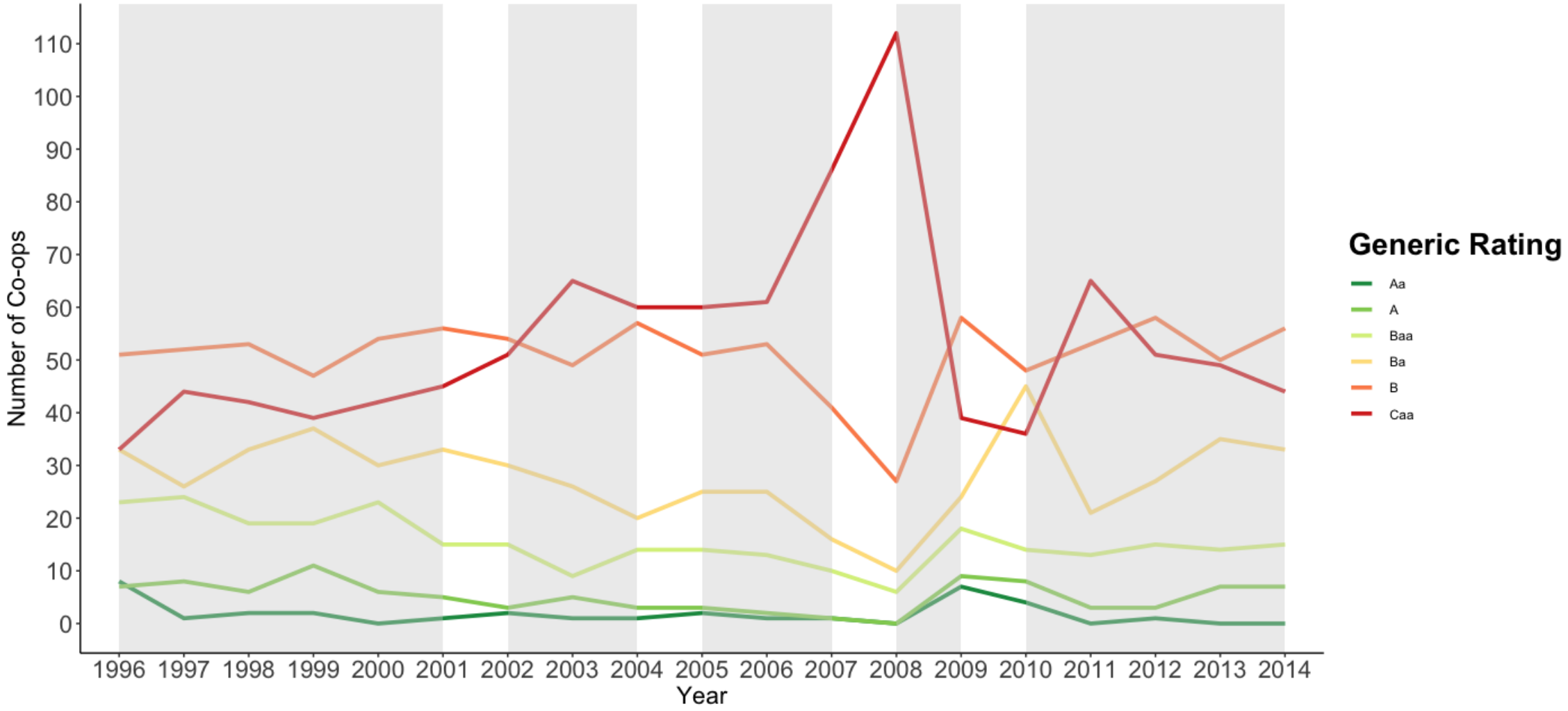



Sources: CoBank

# 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?




Source: CoBank

# 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 | A | Baa | Ba | B | Caa |
| Aa | 0.09 | 0.24 | 0.24 | 0.26 | 0.15 | 0.03 |
| A | 0.04 | 0.23 | 0.30 | 0.30 | 0.07 | 0.06 |
| 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 |
| B | 0.01 | 0.01 | 0.06 | 0.17 | 0.43 | 0.32 |
| 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 | A | Baa | Ba | B | 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 |
| B | 0.01 | 0.03 | 0.09 | 0.18 | 0.33 | 0.36 |
| 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:

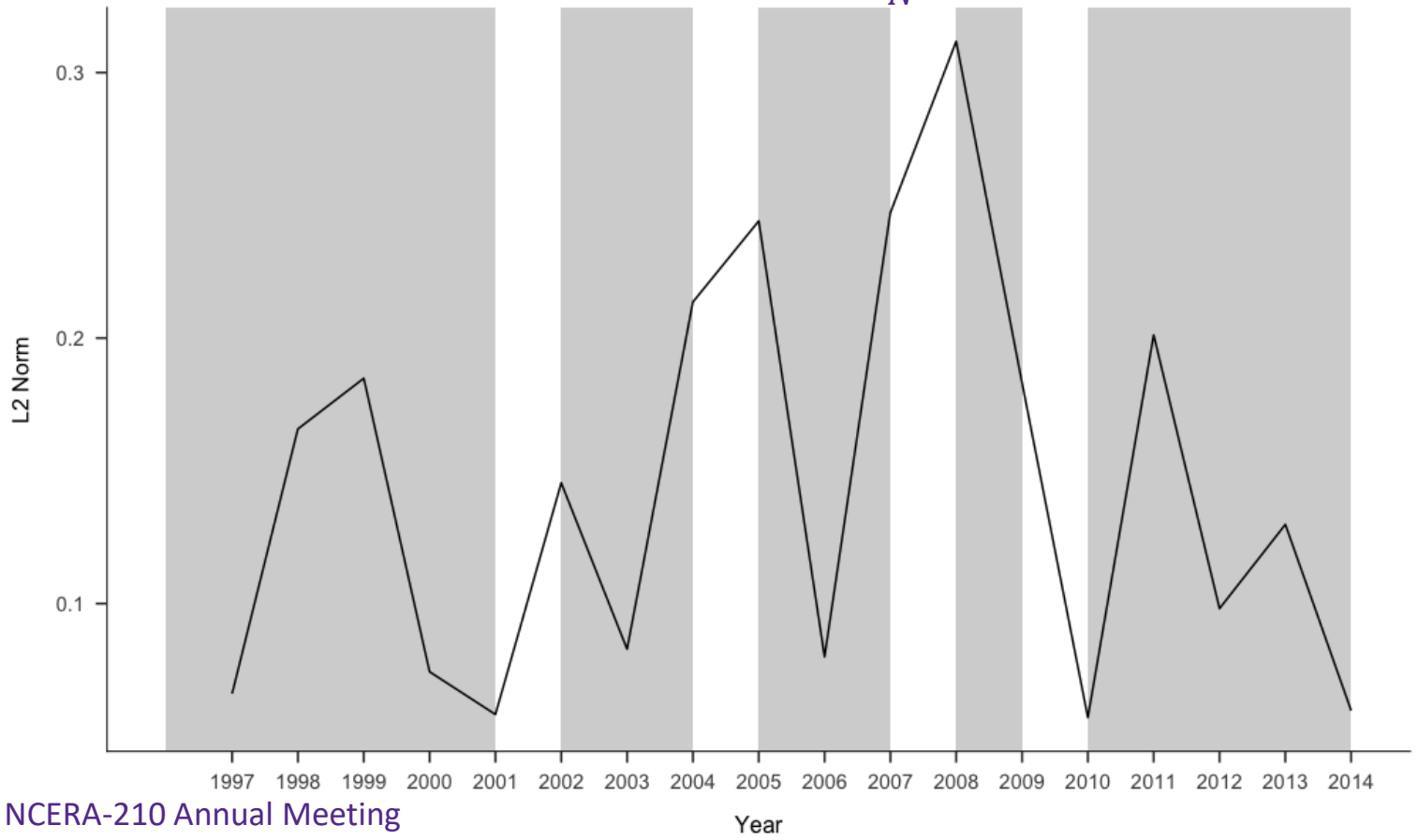
1. The system must be Markovian
   i. Time-Homogenous
   ii. Time-Independent
2. Reliable estimates require a large amount of observations

# 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:

$$\Delta M_{L2}(P_{MLE}, P_m) \triangleq \frac{\sqrt{\sum_{i=1}^{N}\sum_{j=1}^{N}(P_{MLE\,i,j} - P_{m\,i,j})^2}}{N^2}$$



# Test for Time-Homogeneity

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

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

$$Q^{(T)} = \sum_{t=1}^{T} \sum_{i=1}^{N} \sum_{j \in B_i} n_i\,(t) \frac{(\hat{p}_{ij}(t) - \hat{p}_{ij})}{\hat{p}_{ij}} \sim asymptotically \boldsymbol{\chi}^2 (\sum_{i=1}^{N} (a_i - 1)(b_i - 1))$$

- 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 = 0.0000000005670535, 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:
  - $H_0: \forall i: p_{ij} = p_j, where\ (i = 1, \dots, N)$
  - $H_A: \exists i: p_{ij} \neq p_j$
- Results:
  - Chi-Squared Test Statistic= 565.4265, df = 25, p-value = 0.0000000005670535, Reject Null
- Chi-Squared Test Order 1 against Order 2:
  - $H_0: \forall h: p_{hij} = p_{ij}, where\ (h = 1, \dots, N)$
  - $H_A: \exists h: p_{hij} \neq p_{ij}$
- Results:
  - Chi-Squared Test Statistic= 304.3935, df = 150, p-value = 0.000000000001460389, 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 1$^{st}$ – 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

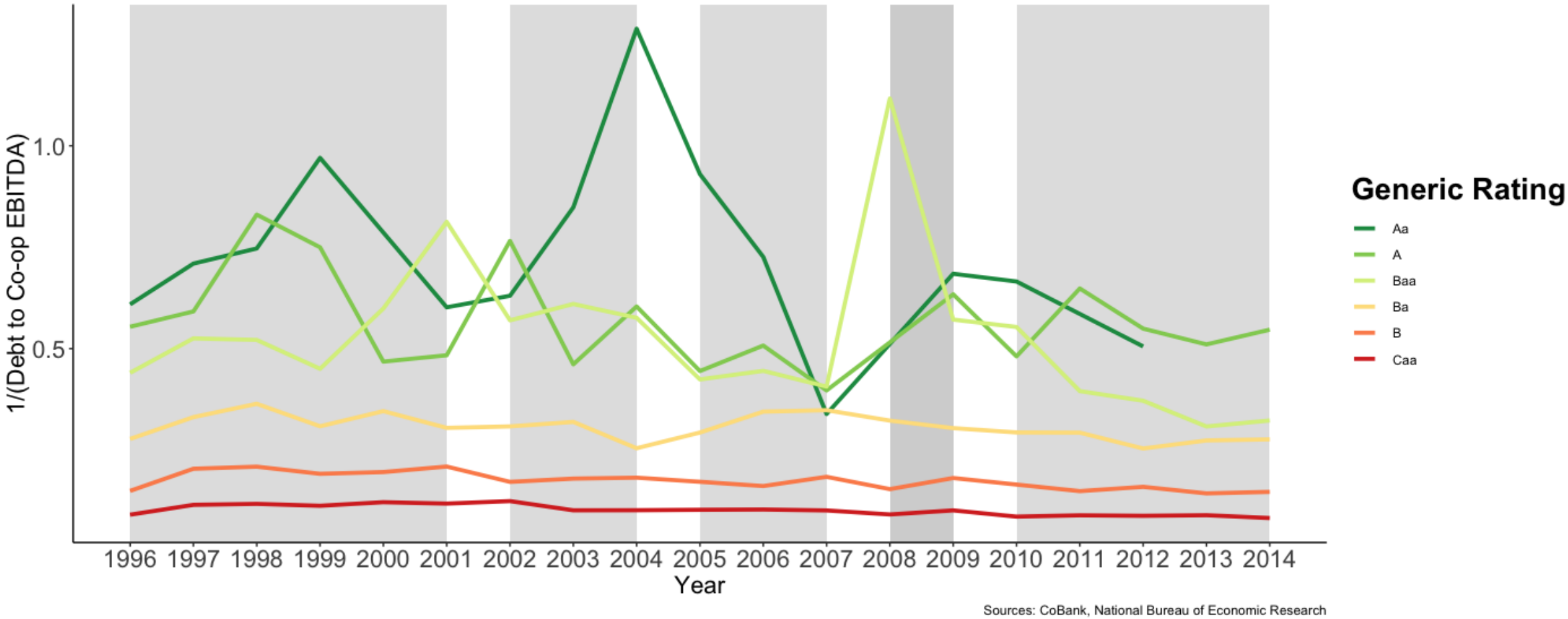
| Period 1 Short Ratings | Period 2 Short Ratings | | | | | |
|---|---|---|---|---|---|---|
| | Aa | A | Baa | Ba | B | Caa |
| Aa | 0.12 | 0.12 | 0.25 | 0.50 | 0.00 | 0.00 |
| A | 0.07 | 0.21 | 0.07 | 0.50 | 0.07 | 0.07 |
| Baa | 0.00 | 0.08 | 0.49 | 0.28 | 0.10 | 0.05 |
| Ba | 0.03 | 0.03 | 0.18 | 0.31 | 0.28 | 0.16 |
| B | 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 1 Short Ratings | Period 2 Short Ratings | | | | | |
|---|---|---|---|---|---|---|
| | Aa | A | Baa | Ba | B | Caa |
| Aa | 0.08 | 0.27 | 0.23 | 0.19 | 0.19 | 0.04 |
| A | 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 |
| Ba | 0.00 | 0.03 | 0.15 | 0.31 | 0.31 | 0.18 |
| B | 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 |

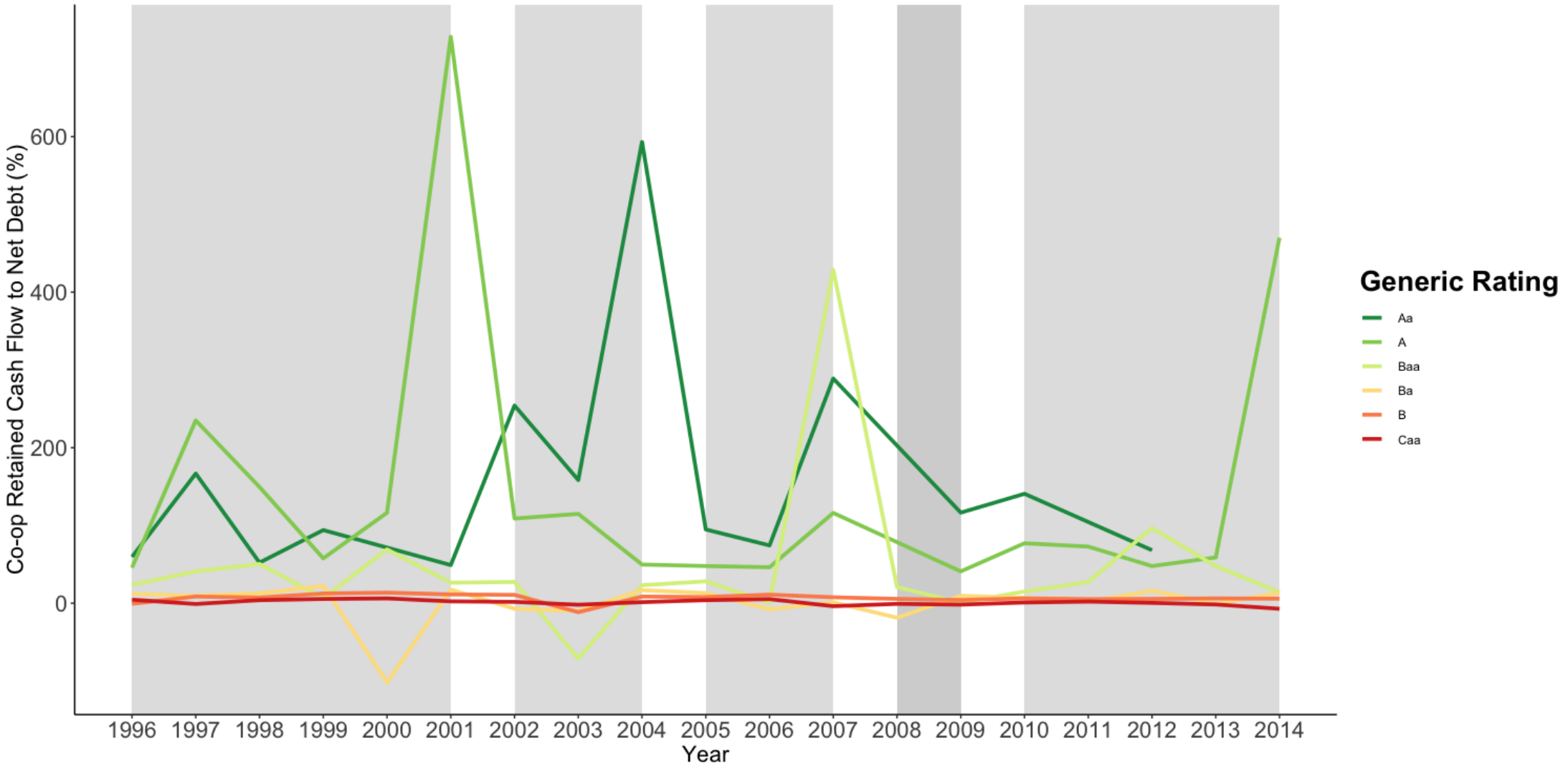
# Debt to Co-op EBITDA

## The Inverse of the ratio to account for outliers




Sources: CoBank, National Bureau of Economic Research

# Co-op Retained Cash Flow to Net Debt




Sources: CoBank, National Bureau of Economic Research

# Co-op RCF Less CapEx to Debt