Modeling Debt Choice in Agriculture: Mixture Models of Operating Margins

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Remembering the 1980s

The crops we grew last summer weren't enough to pay the loan
Couldn't buy the seed to plant this spring and the Farmer's Bank foreclosed
Called my old friend Schepman up to auction off the land.

Well there's ninety-seven crosses planted in the courthouse yard
Ninety-seven families who lost ninety-seven farms
I think about my grandpa and my neighbors and my name
And nights I feel like dyin' Like a scarecrow in the rain

John Mellencamp – Rain on the Scarecrow

Theory of Debt

- Why do farmers borrow money?

$$r_E(t) = \frac{R_P(t)/A(t) + \psi(t)i(t) - k(t)\delta(t)}{1-\delta(t)}$$

$$r_A(t) = \frac{R_P(t)}{A(t)} + \psi(t)\frac{dp_L(t)}{p_L(t)} \Rightarrow m(t) = r_A(t) - K(t)$$

- If there is a positive margin on the investment, borrowing money increases the return on equity

$$\frac{d\,r_E(t)}{d\,\delta(t)} = \frac{R_P(t)/A(t) + \psi(t)i(t) - k(t)}{(1-\delta(t))^2} + \frac{\left[\frac{dR_P(t)}{dA(t)} - \frac{R_P(t)}{A(t)}\right]\frac{1}{A(t)}\frac{dA(t)}{d\delta(t)}}{1-\delta(t)}$$

Optimal Debt

- Holding returns to scale constant, the change in the return to equity gives us the optimal debt expression in the risk-balancing model

$$\delta^*(t) = 1 - \frac{(1-b)\sigma_A^2(t)}{\mu_A(t) - k(t)}$$

$$C^*(t) = E(t)B(t)$$

$$B(t) = \frac{r - k(t)b}{1-b} - \frac{b\left(k(t) - \mu_A(t)\right)^2}{2(1-b)^2\sigma_A^2(t)}$$

Question of Capital Gains versus Operating Returns

- This specification may be somewhat problematic in that the debt-to-asset ratio may not be controllable (at least in the short-run).
  - Differentiating the debt-to-asset ratio yields

$$d\delta(t) = \frac{A(t)dD(t) - D(t)dA(t)}{A^2(t)}$$

$$d\delta(t) = \frac{E(t)}{A(t)}\frac{dA(t)}{A(t)} - \frac{E(t)}{A(t)}\frac{dE(t)}{E(t)}$$

$$= \frac{E(t)}{A(t)}\left[\frac{dA(t)}{A(t)} - \frac{dE(t)}{E(t)}\right]$$

Empirical Analysis

- We use a simple EM [Expectation – Maximization] model to estimate factors affecting the level of debt

$$\delta_{it} = \alpha_0 + \alpha_1 m_{it} + \alpha_2 \dot{p}_{L,it} + \alpha_3 \hat{V}_{it} + \nu_{it}$$

- The data is a panel of the 15 ARMS states.
  - For 1960 through 2003 we use the Financial Condition of the Farm Sector data for each state.
  - For 2004 through 2012 we use the ARMS data
  - The data have been "pasted" together using data from 2003 (which are in both series) and U.S. level data for 1996 through 2003.

Table 1. Finite Mixture Parameters for Return Margin

Parameters	Group			
	1	2	3	4
λ_j	0.1942	0.0918	0.2645	0.4495
μ_j	-0.0858	-0.0676	0.0070	0.0468
σ_j	0.0968	0.1813	0.0322	0.0640
Count	145	16	286	348

Figure 4. Grouping of the Operating Margin, 1961-2012

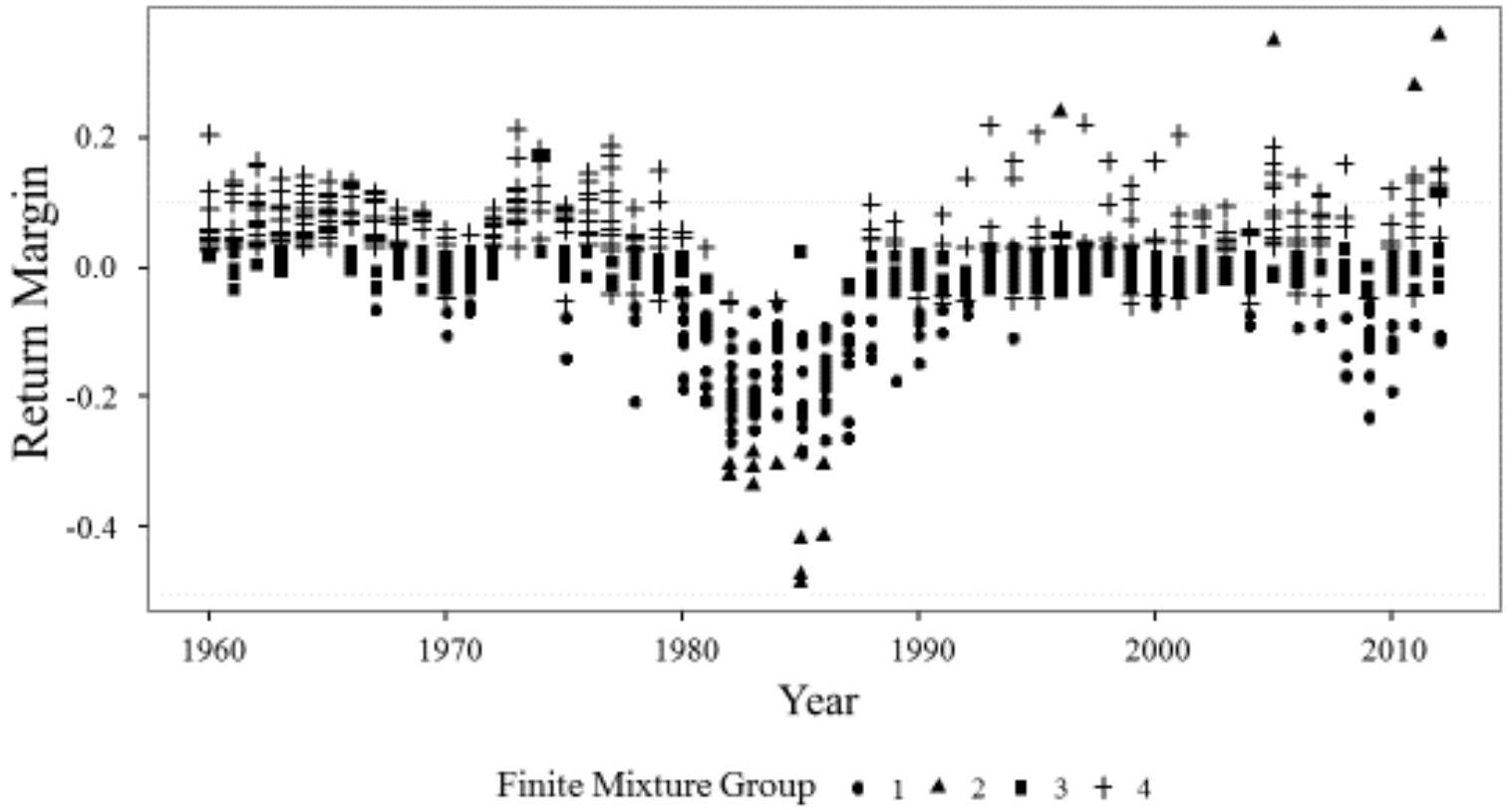
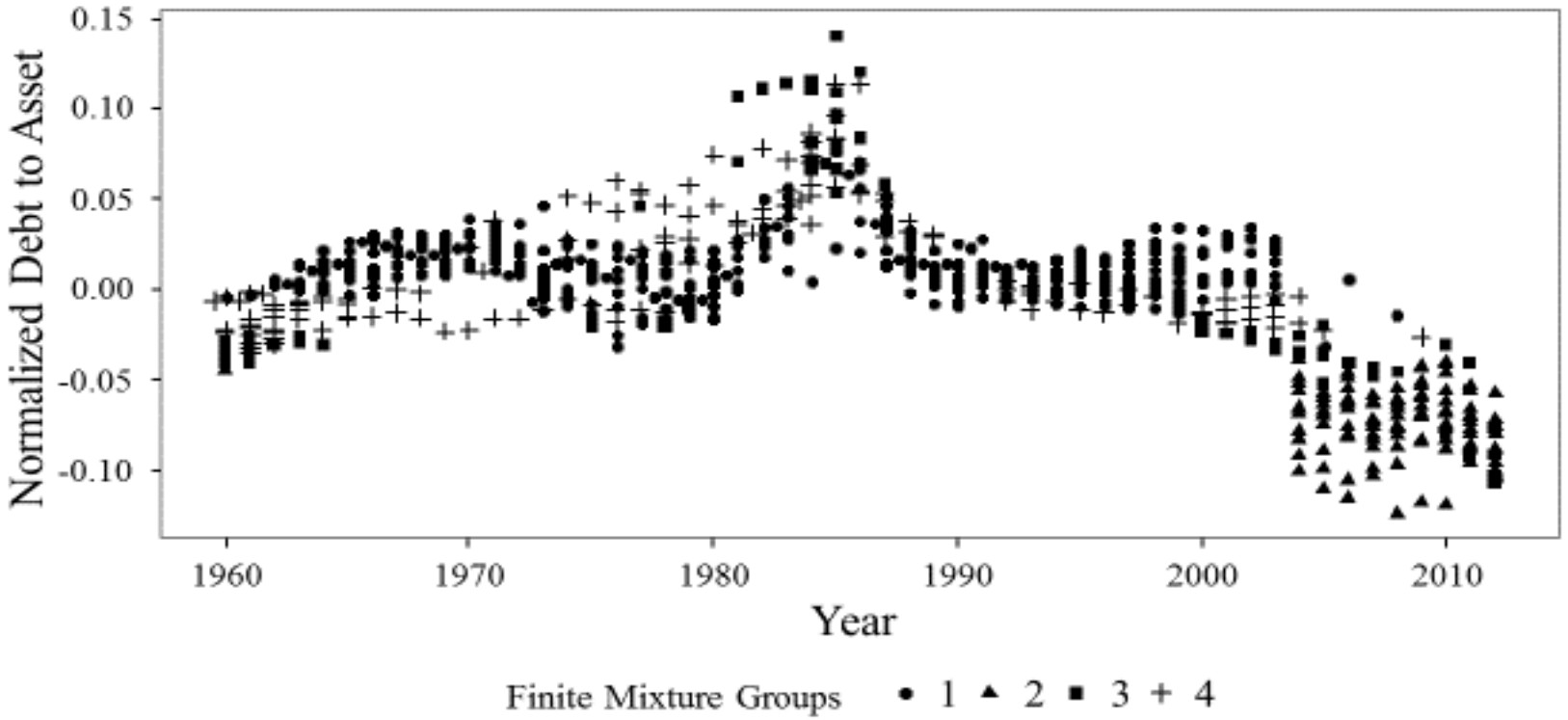


Table 2. Finite Mixture Parameters for the Debt to Asset Specification

	Groups			
	1	2	3	4
Constant (α_{0j})	0.0136***	-0.0705***	0.0024	0.0128***
	(0.0013)	(0.0036)	(0.0046)	(0.0030)
Return Margin (α_{1j})	0.0716***	0.1816**	-0.4139***	-0.2371***
	(0.0226)	(0.0909)	(0.1001)	(0.0560)
Capital Gains (α_{2j})	-0.2002***	-0.1983**	0.0284	0.2325***
	(0.0312)	(0.0859)	(0.0947)	(0.0777)
GARCH (α_{3j})	0.0952***	-0.1522***	0.1731*	0.1444**
	(0.0244)	(0.0481)	(0.1012)	(0.0623)
Count	464	108	74	149

Figure 5. Grouping of the Debt to Asset Ratios, 1961-2012



Discussion

- In 71.9 percent of the estimates the debt to asset ratio increases with an increase in the operating margin and declines with an increase in real farmland.
- In 53.4 percent of all observations (i.e., the subset of 71.9) the debt to asset ratio increases with an increase in risk.
- In 13.6 percent of all observations (i.e., the subset of the 71.9) the debt to asset ratio declines with an increase in risk.
- In 28.1 percent of cases the results do not conform to any theoretical expectation.

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