Debt-Equity Structure and Risk Balancing by Farm Businesses

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Introduction

This study estimates the long-run response of agriculture to changes in agricultural policy through changes in agricultural debt. Significant changes occurred in agricultural policy in the closing years of the 20th century and the first decade of the 21st century. The Federal Agricultural Improvement and Reform Act of 1996 promised a shift to a more market oriented agricultural policy, replacing price deficiency payments with fixed Agricultural Market Transition Act payments that gradually declined over time. However, the ensuing economic climate made a transition to the more market oriented policy untenable. As a result the Food, Security, and Rural Investment Act of 2002 brought back price support mechanisms. Each of these programs has a variety of implications for the farm sector. In general, farm programs tend to increase the rate of return on agricultural assets through price supports, and they also have implications for the riskiness of returns. As discussed by Featherstone *et al.* (1988), these two effects taken together may actually increase the incidence of catastrophic risk (i.e., bankruptcy) by inducing farmers to take on additional leverage. Thus, the effect of these changes in farm policy on the economic stability of the farm sector is intimately linked to debt decisions made with respect to the potential changes in expected returns and relative risks.

Most research on agricultural debt over the past quarter century can be traced to the risk-balancing formulation proposed by Collins (1985). This model hypothesizes that decision makers choose the level of debt that maximizes their expected utility of future income. The result is an optimizing behavior that balances increased expected return to equity against the additional risk inherent with leverage. This basic formulation has been extended and refined by Ramirez, Moss, and Boggess (1997) using stochastic optimal control rather than a single period model, but the basic structural implications of the model remain unchanged. Featherstone *et al.* use the Collins formulation to investigate the theoretical linkages between farm programs and debt decisions. Specifically, they show that government programs may induce either increased or decreased leverage depending on the producer's aversion to risk and the impact of government programs on the moments of the profit distribution. Moss, Shonkwiler, and Ford (1990) find empirically that increased risk implies lower leverage, which supports Featherstone *et al.*'s risk-balancing arguments that reducing the variability in net returns government programs may have increased the probability of financial stress in the farm sector.

In developing their theoretical model Featherstone *et al.* assume a constant absolute risk aversion coefficient of 0.15. Moss, Ford and Boggess use the same framework to examine the effect of changes in the tax code on debt levels. They vary the relative risk aversion coefficient between 0.01 and 1.76 to observe the full range of possible debt-to-asset positions (0.0 to 1.0). Moss, Shonkwiler, and Boggess use an autogressive conditional heteroscedasticity formulation assuming the absolute risk aversion coefficient is constant over time to estimate the risk-balancing model. However, they do not explicitly estimate the risk aversion coefficient. Ramirez,

Moss, and Boggess develop a stochastic optimal control formulation of the original risk balancing framework. They consider two risk aversion coefficients. The first is based on Ramirez's (1990) generalized method of moments estimator, 1.57, and the second is based on the mean and variance of the rate of return on agricultural assets in there sample and the average debt-to-asset position, 2.07. The range of risk aversion coefficients presented in the literature raises significant questions regarding the reaction of agricultural leverage to recent changes in domestic farm policy. Further, the typical assumption among studies that have estimated, implicitly or explicitly, risk aversion is that the risk aversion coefficient for farmers is constant over time.

Risk Aversion in the Risk-Balancing Model

Collins' formulation of the risk-balancing model builds on the Gabriel and Baker's (1980) formulation where the decision-maker uses debt to control the financial risk of any particular level of business risk. Specifically, the rate of return to equity is modeled as:

$$R_E = \left[\frac{r_P}{A} + i - K\delta \right] \frac{1}{(1-\delta)} \tag{1}$$

where R_E is the rate of return to equity, r_P is the operating return to agricultural assets, A is the level of agricultural assets, i is rate of capital appreciation, K is the cost of capital, and δ is the total liabilities over total assets. This notation is typically simplified by collapsing the operating return to agriculture and the rate of capital appreciation into a single rate of return on agricultural assets.

Following the aggregation of operating returns and capital appreciation into a single return on agricultural assets, R_A; we denote the expected rate return on agricultural assets as μ_A with variance σ_E^2. The variance of the rate of return on equity then becomes

$$\sigma_E^2 = \sigma_A^2 \frac{1}{(1-\delta)} \tag{2}$$

which is consistent with the principle of increasing risk (i.e., that increasing levels of leverage result in increasing risk in the return to equity). The optimal debt-to-asset ratio derived by Collins is then:

$$\delta^* = 1 - \frac{\rho\sigma_A^2}{(\mu_A - K)} \tag{3}$$

where ρ is the relative risk aversion coefficient. Taking the first-order Taylor series approximation of the natural logarithm of both sides of Equation 3 yields

$$\ln(\delta^*) = \ln(\delta_0) + \frac{1}{1 - \frac{\rho\sigma_0^2}{x_0}} \left[-\frac{\rho}{x_0} \left(\sigma^2 - \sigma_0^2 \right) \right] + \frac{1}{1 - \frac{\rho\sigma_0^2}{x_0}} \left[\frac{\rho\sigma_0^2}{x_0^2} \left(x - x_0 \right) \right]$$

$$= \ln(\delta_0) - \frac{\rho}{x_0 - \rho\sigma_0^2} \left(\sigma^2 - \sigma_0^2 \right) + \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \frac{1}{x_0} \left(x - x_0 \right) \tag{4}$$

where $x = \mu_A - K$ or the expected returns over the cost of capital for a particular region or time period, and x_0 and σ_0^2 are the sample means used as the point of approximation. Next, by logarithmic differentiation

$$\sigma^2 - \sigma_0^2 = d\,\sigma^2 = \sigma^2 d\ln(\sigma^2) \Leftarrow d\ln(\sigma^2) = \frac{1}{\sigma^2} d\ln(\sigma^2)$$

$$\approx \sigma_0^2 \left(\ln(\sigma^2) - \ln(\sigma_0^2) \right)$$

$$x - x_0 = d\,x = x\,d\ln(x) \Leftarrow d\ln(x) = \frac{1}{x} d\ln(x)$$

$$\approx x_0 \left(\ln(x) - \ln(x_0) \right)$$

(5)

Substituting these results into Equation 4 yields

$$\ln(\delta^*) = \ln(\delta_0) - \frac{\rho}{x_0 - \rho\sigma_0^2} \sigma_0^2 \left(\ln(\sigma^2) - \ln(\sigma_0^2) \right) + \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \frac{1}{x_0} x_0 \left(\ln(x) - \ln(x_0) \right)$$

$$= \ln(\delta_0) - \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \left(\ln(\sigma^2) - \ln(\sigma_0^2) \right) + \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \left(\ln(x) - \ln(x_0) \right)$$

(6)

$$= \left[\ln(\delta_0) + \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \ln(\sigma_0^2) - \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \ln(x_0) \right] - \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \ln(\sigma^2) + \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \ln(x)$$

Transforming the model in Equation 6 into an estimable form

$$\ln(\delta^*) = \beta_0 + \beta_1 \ln(\sigma^2) + \beta_2 \ln(x)$$

$$\beta_0 = \left[\ln\left(1 + \frac{\rho\sigma_0^2}{x_0} \right) + \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \ln(\sigma_0^2) - \frac{\rho\sigma_0^2}{x_0 - \rho\sigma_0^2} \ln(x_0) \right]$$

$$\beta_1 = -\frac{x_0}{x_0 - \rho\sigma_0^2}$$

(7)

$$\beta_2 = \frac{x_0}{x_0 - \rho\sigma_0^2}$$

or $\beta_1 = -\beta_2$.

Apart from the test of the general hypothesis, the estimated parameters can be used to recover an aggregate estimate of sector risk aversion coefficient. Using the results from Equation 7

$$\beta_1 = -\frac{x_0}{x_0 - \rho\sigma_0^2} \Rightarrow \rho = \frac{x_0 - x_0\beta_1}{\beta_1\sigma_0^2}$$

(8)

$$\beta_2 = \frac{x_0}{x_0 - \rho\sigma_0^2} \Rightarrow \rho = \frac{\beta_2 x_0 - x_0}{\beta_2\sigma_0^2}.$$

Given that ρ in this formulation is an Arrow-Pratt relative risk aversion coefficient, we anticipate a positive number in the zero to 7 range.

Data

Data for the analysis are from the 1996-2003 Agricultural Resources Management Study (ARMS). The ARMS, which has a complex stratified national annual survey of farms, is conducted annually by the Economic Research Service and the National Agricultural Statistics Service. The survey collects data to measure the financial condition (farm income, expenses, assets, and debts) and operating characteristics of farm businesses, the cost of producing agricultural commodities, and the well-being of farm operator households. The survey design of the ARMS allows each sampled farm to represent a number of farms that are similar, also referred to a survey expansion factor. The expansion factor, in turn, is defined as the inverse of the probability of the surveyed farm being selected.

The target population in the survey is operators associated with farm businesses representing agricultural production across the United States. A farm is defined as an establishment that sold or normally would have sold at least $1,000 of agricultural products during the year. Farms can be organized as proprietorships, partnerships, family corporations, nonfamily corporations, or cooperatives. Data are collected from one operator per farm, the senior farm operator. A senior farm operator is the operator who makes most of the day-to-day management decisions.

Each farm in the survey reports its income, assets, and debt; the debt-to-asset ratio is calculated based on that information. Further, because of the differences across regions in the structure of agriculture, data also classifies each farm into nine different region of the United States. Location of the farm (region) has its potential for influencing the level of income, assets, and debt, and debt-equity; risk balancing is examined by nine distinct farm-resource regions (Figure 1). Additionally, farms within a region tend to be similar in terms of soil condition, crop and livestock produced. It is easier to estimate the average rate of return to assets and variance of rate of return to assets using regional estimates. Specifically, using the ARMS dataset we have a sample of rates of return on agricultural assets for each region that can be used to estimate the expected rate of return and variance of the rate of return of agricultural assets. Other data sources (i.e., the state-level income statements and balance sheets for the farm sector) only yield one observation on the rate of return to agricultural assets. Hence, other studies such as Moss et al. (1990) hypothesize elaborate time-series models to recover information on the expected rate of returns and the variance of the rate of return on agricultural assets.

Empirical Model and Estimation Procedure

To empirically estimate Equation 7, we compute the average rate of return to assets, variance of the rate of return to assets, the effective interest rate, and the average leverage (debt-to-asset ratio) positions for each of the nine regions (Figure 1) from 1996 to 2003. The following model was estimated.

$$\ln(DA_{it}) = \beta_0 + \beta_1 \ln(\pi_{it}) + \beta_2 \ln(VROA_{it}) \quad i = 1, \cdots 9 \ \text{ and } t = 1996, \cdots 2003 \qquad (9)$$

where DA is the leverage (debt-to-asset) ratio in region, π is the profit margin (that is average rate of return to assets less cost of capital (interest rate), and $VROA$ represents the variance of the

rate of return to assets. The average rate of return to assets includes capital gains. State level data on average capital gains was used to derive per farm capital gains in the ARMS data. In particular the average rate of capital gains in the State was multiplied by the value of farm and buildings on surveyed farm.

The problem when using time series and cross-sectional data (or panel data) to estimate a relationship is to specify a procedure that will adequately allow for differences in behavior over cross-sectional units, in our case the farming regions, as well as for differences in behavior over time for a given cross-sectional unit (Judge *et al.* 1985). Fixed effects regression is a method of controlling for omitted variables in panel data when the omitted variables vary across entities but do not change over time. The fixed effects regression model has n different dummy intercepts, one for each entity. These intercepts can be represented by a set of binary variables that differ from one entity to the next but are constant over time. Just as fixed effects for each entity can control for variables that are constant over time but differ across entities, so can time fixed effects control for variables that are constant across entities (region) but evolve over time.

To test if some omitted variables are constant over time but vary across regions, while other variables are constant across states but vary over time, we include both location (region) and time effects (year). This is done by including both $n-1$ region binary variables and $T-1$ time binary variables in the regression, plus an intercept. The combined time and entity fixed regression model is

$$y_{it} = \alpha_0 + \alpha_i + \gamma_t + \beta' X_{it} + \varepsilon_{it,} \tag{10}$$

This model has an overall constant term as well as a "group" effect for each group and a "time" effect for each time period. The "dummy variable trap" is avoided by setting

$$\sum_i \alpha_i = \sum_t \gamma_t = 0. \tag{11}$$

The combined time and region fixed effects regression model eliminates omitted variables bias arising both from unobserved variables that are constant over time and from unobserved variables that are constant across regions. Additional observed "X" regressors would also appear in Equation 6.

Results

In general the results of the panel estimation presented in Table 1 are consistent with the debt-balancing model proposed in the literature. On average, increased operating margins over the cost of capital result in increased debt-to-asset ratios, further this effect is statistically significant at the 0.05 level of confidence. In addition, increased risk manifest through increased variance in the rate of return on assets implies a reduction in the optimal debt-to-asset ratio. The effect of risk on the debt-to-asset ratio is statistically significant at the 0.01 level of confidence. Next, we test the restriction that $\beta_1 = -\beta_2$, which we reject at the 0.05 level of confidence. Thus, while the empirical results are consistent with the basic risk-balancing model, the parameter estimates themselves do not satisfy the overidentifying restrictions of the model (i.e., each estimated parameter implies a different risk aversion coefficient through Equation 8).

Conclusions

This study examines aggregate evidence of the risk-balancing debt-choice hypothesis for U.S. agriculture using a panel data. The empirical results support the hypothesis of risk balancing in that aggregate agricultural debt increases as the return margin defined as the rate of return on agricultural assets less the cost of debt capital increases, and declines as the standard deviation of the same margin increases. However, the model rejects the overidentifying conditions from the Collins formulation. Specifically, the implied risk aversion coefficient is different for each effect. The rejection of the overidentifying conditions raises several possibilities. First, adjustment may be sticky because of asymmetries in the capital market. Thus, farmers may only be able to purchase farmland in discrete quantities (i.e., 160 acre blocks). Second, we may have a measurement error problem, particularly in the case of the variance of the operating margin. However, uncorrelated measurement error typically attenuates the statistical significance of the estimated coefficient. Third, the panel formulation may be inappropriate. In this study we have used the USDA Farm typology to form our panels. Finally, the optimal debt formulation may be misspecified in some way. As indicated above, the optimum debt formulation is fairly robust. Ramirez, Moss, and Boggess reformulated the problem using stochastic optimum control to find a nearly identical specification.

References

Collins, R.A. "Expected Utility, Debt-Equity Structure, and Risk Balancing." *American Journal of Agricultural Economic* 67(1985): 627–9.

Featherstone, A.M., C.B. Moss, T.G. Baker, and P.V. Preckel. "The Theoretical Effects of Farm Policies on Optimal Leverage and the Probability of Equity Loss." *American Journal of Agricultural Economics* 70(1988): 572–9.

Gabriel, S.C. and C.B. Baker. "Concepts of Business and Financial Risk." *American Journal of Agricultural Economics* 62(1980): 560–4.

Judge, G.G., W.E. Griffiths, R.C. Hill, H. Lutkepohl, and T.-C. Lee. *Theory and Practice of Econometrics*, 2nd Edition New York: John Wiley & Sons, 1985.

Moss, C.B., S.A. Ford, and W.G. Boggess. "Capital Gains, Optimal Leverage, and the Probability of Equity Loss: A Theoretical Model." *Agricultural Finance Review* 49(1989): 127–34.

Moss, C.B., J.S. Shonkwiler, and S.A. Ford. "A Risk Endogenous Model of Aggregate Agricultural Debt." *Agricultural Finance Review* 50(1990): 73–9.

Ramirez, O.A. "A Stochastic Optimal Control Formulation of the Risk Balancing Debt Choice Model: A Basis for the Generalized Method Moments Estimation of Risk Aversion Coefficients." Unpublished Ph.D. dissertation, Food and Resource Economics Department, University of Florida, Gainesville, 1990.

Ramirez, O., C.B. Moss, and W.G. Boggess. "A Stochastic Optimal Control Formulation of the Consumption/Debt Decision." *Agricultural Finance Review* 57 (1997): 29–38.

Table 1: Debt structure and risk by farming regions in U.S. (1996-2003): Two-way fixed effects

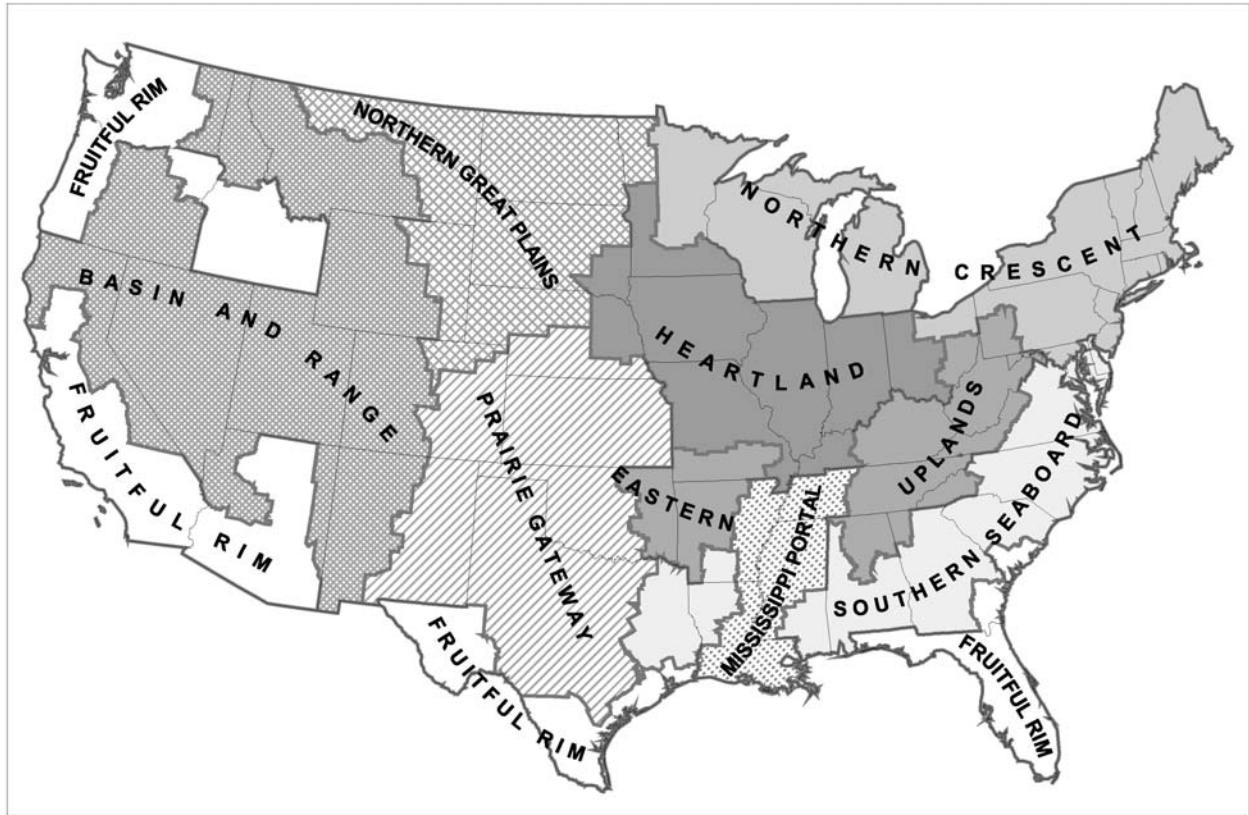| Variables	Parameter estimates
Intercept	-2.988
	(0.349)
Log of margin (difference between the average rate of return on assets and the average cost of capital	0.163
	(0.083)**
Log of variance in returns to assets (including capital gains)	-0.081
	(0.023)***
R-squared	0.66
Fixed effects	
Year: (*f-value*)	1.55
Regions: (*f-value*)	2.72**

Figure 1: ERS resource regions