Farmland Values, Government Payments, and the Overall Risk to U.S. Agriculture: A Structural Equation-Latent Variable Model

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Abstract

According to Ricardian rent theory, the value of farm assets is equal to the discounted present value of future expected net rents from farm returns, and the discounted expected value of the land if converted to nonfarm development. Some recent research has considered modifying this standard present value model by acknowledging that returns from the market may be discounted at a different interest rate than returns from government payments (Goodwin, Mishra, and Ortal-Magne) and also that the discount rate itself may be time-varying. However, very little research has considered how changes in the overall risk to agriculture may affect farmland values. An exception is Moss, Shonkwiler and Schmitz (2004). We use time series panel data from the USDA for United States, 1960-2004 and a structural equations model with latent variables for the rate of return on farm assets and for the real risk-adjusted interest rate. We find that a secondary effect of agricultural policies that reduces the overall risk to agriculture may increase farmland values (and thus farm sector wealth). Government payments are offsetting the negative impact of high volatility of returns to farming.

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1. Introduction

Farmland values in the United States represent a major component of the farm sector balance sheet. Farmland values accounted for an average of 70 percent of total U.S. agricultural assets between 1960 and 2004. This is important for several reasons. First, the opportunity cost of farmland represents a major production expense. Second, the farm sector's solvency is intimately linked to the value of farmland. Third, the valuation of farmland has a significant effect on the estimation of sector productivity and competitiveness. Fourth, the linkage between sector solvency and farmland values may also increase the coupling of farm program payments to current production decisions, driving a "wedge" between the market price of farmland and its true shadow price (opportunity cost) and leading to allocational inefficiencies.

The face of agriculture is changing constantly due to changes in trade, production, and marketing of agricultural products. Today farmers face very competitive environment and have to act judiciously in order to capitalize on information and maximize profits. On the other hand, the risk associated with production agriculture is no easy task for farmers. Farmer has to evaluate investment strategies in agriculture and must be accompanied by an investigation of the effect of uncertainty and risk. This is also the case with decision to invest in farmland. According to Ricardian rent theory, the value of farm assets is equal to the discounted present value of future expected net rents from farm returns, and the discounted expected value of the land if converted to nonfarm development. Some recent research has considered modifying this present value model by acknowledging that returns from the market may be discounted at a different interest rate than returns from government payments (Goodwin, Mishra, and Ortal-Magne, 2004) and that the discount rate itself may be time-varying. However, very little research has considered how changes in the overall risk to agriculture may affect farmland values. Barry (1980) and Bjornson and Innes (1992) examined the role of risk is the valuation in farm assets. However, their analysis focused on risk in agriculture with respect to a market portfolio and assumes that relative risk of farm assets remained constant over time. Although it is commonly recognized that farm programs increase the net return to farmland, their (potential) risk-reducing impacts are not as well understood (Moss, Shonkwiler and Schmitz (2003). This study estimates the effect of uncertainty on farmland values in the ten regions of the United States using an option pricing approach. We use time series (1960-2004) panel data from the ten regions and a structural equations model with latent variables to estimate the effect o risk on farmland values. Specifically, we use a structural model of latent variables (Bollen, 1989) to estimate the effect of risk, within both interest rates and returns to agriculture on certainty equivalence[1]. Our null hypothesis is that the certainty equivalence due to the risk in returns to farmland does not vary over time and region.

2. The Empirical Model:

Following the development of Schmitz and Schmitz and Moss (2003), we use the traditional present value theory to specify farmland values using the expected value of future returns.

$$V_t = \sum_{i=1}^{N} \frac{E_t CF_{t+i}}{\prod_{j=1}^{i}\left(1 + r_{t+j}\right)} \tag{1}$$

[1] Certainty equivalence is defined as the ratio of imputed value of farmland divided by the observed 2006 market value of land.

where V_t is the price of farmland, $E_t CF_{t+i}$ is the expected return to farmland in period t+i based on information available in period t, r_{t+j} is the appropriate discount rate in period t+j, and N is the planning horizon for the investment. In the case of farmland we assume that N→∞. This specification

Following the certainty equivalent model of Moss, Shonkwiler, and Schmitz (MSS, 2003) we determine the effect of a change in the perceived relative risk for farm asset values over time by observing the change in the value of θ_t, a multiplier that accounts for the reaction of the market to uncertainty. To derive an estimate of θ_t, MSS compute an imputed asset value based on USDA historical data on farmland prices and returns to farm assets. The interest rate is the commercial paper rate published by the Federal Reserve Board of Governors. The imputed asset return is derived as

$$\tilde{V}_t = \sum_{i=0}^{N} CF_{t+i} / \prod_{j=0}^{i} (1 + r_{t+j}) \tag{2}$$

where $\tilde{V}_t$ is the imputed value of farmland over the observed planning horizon and CF_{t+i} is the observed cash flow to agricultural assets in period *t+i,* and r_{t+j} is the interest rate in period *t+j.*

One can use the irreversibility framework as discussed by Dixit and Pindyck (1994) the features of agriculture resemble financial call options. The authors claim that thinking of investment as options changes and elaborate the theory and practice of decision making about capital investment, in our case farmland. Following Dixit and Pindyck (1994) one can formulate the risk-adjusted asset value as:

$$V_t = \theta_t \sum_{i=0}^{\infty} \frac{E_t(CF_{t+i})}{\prod_{j=0}^{i}(1 + r_{t+j})} \quad (3)$$

where the θ_t is a multiplier that accounts for the reaction of the market uncertainty. Intuitively, we expect that $0 < \theta_t < 1$, with $\theta_t \to 0$ as the returns from the farm assets (farmland) become less risky. In order to compute the present value of assets (farmland) to perpetuity, on e can compute

$$\widehat{V_t} = \frac{V}{1 - \left(\frac{1}{1 + \overline{r_t}}\right)^N}, \quad (4)$$

Where $\widehat{V_t}$ the imputed regional farmland is value and $\overline{r_t}$ is the average interest rate in the region. Equation 3 can be rewritten as $V_t = \theta_t \widehat{V_t}$. Dividing both sides of equation by the imputed farmland value yields an empirical estimate of θ_t.

In his original article Dixit (1992) described optimal timing of an investment as a tangency between the value of investing and the value of waiting to invest. Dixit and Pindyck (1995) point out that optimal capital investments or irreversible investments opportunities are like financial call options and the decision rule for investing in the option framework is to invest when the value of investing exceeds the value of waiting. Specifically, in the case of farmland, the decision is to invest if the annual return is greater than the threshold rate. The value-matching conditions and the smooth-pasting conditions are satisfied simultaneously (Dixit (1992)

$$H = \frac{\beta}{\beta - 1} \delta K \quad (5)$$

Where β is defined as $\beta = \frac{1}{2}\left[1 + \sqrt{1 + \frac{8\delta}{\sigma^2}}\right]$ where δ is the opportunity cost of capital or a risk-adjusted discount rate, K is the value of the asset (farmland), and σ^2 is the variance of the stochastic process determining the rate o return. Moss, Shonkwiler, and Schmitz (2002) point out that in equation 5 that $\beta \rightarrow \infty\ as\ \sigma^2$ or the investment becomes risky. The authors conclude that the gap between the imputed present value and the market value of the farmland is a function of the annual rate of return to farm assets, the risk-adjusted discount rate, and the variability of agricultural returns (figure 1). We slightly modified MOSS model to include separate latent variable for government payment, and we used risk adjusted interest rate to accommodate both the risk free interest rate and its volatility. We specify an empirical model of θ_t as follow:

$$\frac{1}{\theta_t} = \varphi_0 + \varphi_1 r_t^a + \varphi_2 r_t^f + \varphi_3 \sigma_{a,t}^2 + \varphi_4 G_t \qquad (6)$$

where r_t^a is the real rate of return to agricultural assets in period t excluding government payment, r_t^f is the risk adjuster interest rate in period t, $\sigma_{a,t}^2$ is the volatility of the real rate of return on agricultural assets, and G_t is the government payments per acre (in real terms) at time t. In agriculture the volatility of the rate of return on agricultural assets is unobserved and the appropriate real rates of return are the ex ante rates. To address these issues and following Bollen (1989) we use a structural latent-variable approach. Specifically, an unobserved variable ω that represents the true certainty equivalence is postulated to be a function of four latent variables

$$\omega_t = \varphi_1 \zeta_{1t} + \varphi_2 \zeta_{2t} + \varphi_3 \zeta_{3t} + \varphi_4 \zeta_{4t} + v_t \,. \qquad (7)$$

where ζ_{1t} is the latent expectation of the real rate of return on farmland, ζ_{2t} is the latent expectation of the risk adjusted interest rate, ζ_{3t} is the latent variance of the real rate of return on farmland, ζ_{4t} is the latent variance of the government payments and ν_t is the error certainty equivalence.

To quantify these latent independent variables, we use a set of observable indicators where x_{1t} is an autoregressive estimate of the real rate of return on agricultural assets, x_{2t} is the observed farm interest rate, and $x_{3t} \ldots x_{5t}$ are *t* through *t*-2 lagged standard deviations of the errors of the autoregressive models of real rate of return on the farm land, and δ_{it} are errors of measurement. This is a *confirmatory factor analysis*, with the common portion of the variance between $x_{3t} \ldots x_{5t}$ representing the current expectation of volatility of the real return rate. Analytically, the equation of the measurement model for a given region can be at time period t can written as follow:

$$X_t = \Lambda \xi_t + \delta_t \qquad t = 1 \ldots T \qquad (8)$$

Where X is 5×1 vector of observable indicators, Λ is 5×4 matrix of the coefficients of the exogenous latent variables ξ ,and δ is q×1 vectors of measurement errors.

The structural equation model (7) can be written in matrix notation as follow:

$$\omega_t = \Gamma \xi_t + \varepsilon_t \qquad (9)$$

Where ω is the latent variable for the inverse of certainty equivalence $\frac{1}{\theta_t}$ at time t. and Γ is 1×4 matrix of the coefficients of the latent variables ξ in the structural equation. and ε measurement error of the structural equation. Since the instantaneous volatility of the rate of return is unobserved, the appropriate real rates of return are ex ante rate, and a proxy measures the dependent variable, we (like MSS) use a structural latent variable approach (Bollen 1989).

3: Data and Estimation Procedure:

To incorporate the regional perspective of our analysis we use U.S. Department of Agriculture, Economic Research Service's state-level data for 46 states (excluding Alaska, Hawaii, Pennsylvania and West Virginia[2]), 1960-2004, and group them into 10 production regions. The regions are: Northeast, Lake States, Corn Belt, Northern Plains, Appalachia, Southeast, Delta, Southern Plains, Mountain, and Pacific. Farmland values by state are based on the estimates of value of the farmland published by National Agricultural Statistics Service and Economic Research Service of the USDA. Figure 2 shows regional differences in farmland value over 1960-2004 period. Returns to farm assets (land and other farming assets) is derived in a manner similar to Melichar (1979). Average real interest rate is the average interest rate on farm business debt (i.e., ratio of interest expenses to outstanding farm debt). Finally, the debt-servicing ratio is computed as the ratio of principal repayments plus interest expenses, excluding interest expenses associated with the operator's dwelling, to gross farm income. These annual data on farmland values, average interest rates, returns to farm assets, share of government payments to total cash income, and debt-servicing ratio are derived from a variety of sources such as the Census of Agriculture, various USDA agencies, Federal Deposit Insurance Corporation (FDIC) call reports, and the Farm Credit System. Farmland values and returns to farm assets are deflated using the implicit GDP deflator, 1992=100. Table 1 provides the summary statistics of the variables used in the estimation of the model.

[2] Complete dataset for these states were not available.

An SEM is estimated by first fitting autoregressive models for the real interest rate and real returns on farm assets. Predictions from the autoregressive models are assumed to provide the true ex ante estimates of the real interest rate and the real rates of return to agricultural assets. We estimate system of equations by centering the data on their means and maximizing the likelihood function. The Maximum likelihood method is chosen to estimate the model .This method gives efficient estimates and is expected to be robust to minor violation of the multivariate normality assumption of the model.

4. Results and Discussion

Results of the measurement model support the hypothesis that the proposed theoretical model has an adequate fit in almost all regions (Table 1). The value of the chi-square statistics of the model fits was insignificant in all regions. Furthermore, other model fit measures such as the residual mean square error estimate (RMSE), the Adjusted goodness fit index (AGFI) are also in agreement with this hypothesis. One borderline exception is the Lake state region which has somehow poor model fit compared to other regions. The value of AGFI index for this region is 0.78<0.90 , and it has quite large estimate for the RMSE estimate (0.06), compare to other regions. With the exception of the Appalachia region, all the coefficients of the indicator variables have the expected theoretical signs and statistically significant at either 5% or 10% level of significance. This indicates that these indicator variables have adequately captured the impacts of the latent variable factors that they are supposed to measure.

The results of the structural model presented in Table 2 indicate that the estimated effect of the latent variable of the real interest rate is negative and highly significant at 5% level of significance for four regions. These regions are Northeast, Corn Belt, Appalachian, Southeast, Delta, and Southern Plains. The negative sign on this variable is in consistent with the theoretical expectation. Specifically, results indicate that higher levels of the real interest rate decreases the option value of waiting $\left(\frac{\beta}{\beta - 1} - \frac{1}{\theta}\right)$, and consequently, the higher the certainty equivalence of the farmland assets.

Even though, the coefficient of latent variable for the government payments has the theoretical expected sign (negative) across several regions, it was only statistically significant at 5% level in the Pacific region. The negative sign on this latent variable indicates that an increase in government payments causes the ratio of the market value of the farm assets to its imputed value to increase. The negative relationship between government payments and the inverse of certainty equivalence implies that the relationship between the government payments and the certainty equivalence is positive. This is consistent with the fact that government payments decrease variability in income (Mishra and Sandretto, 2002) and hence increase the farmland value through capitalization of government payments into farmland (Goodwin, Mishra, and Ortal-Magne, 2004). Findings are consistent with previous research findings (Lence and Mishra, 2004; Goodwin, Mishra, and Ortal-Magne, 2004). Further, the negative coefficient on government payments supports the hypothesis that government programs increase the values of the agricultural assets not only through the increase in agricultural returns, but also through the reduction of the risks associated with these returns.

Finally, the result of the structural equation model indicates that the estimated effect of the volatility of returns of agricultural assets was positive and statistically significant at the 10% level in only one region (the Corn Belt region). Specifically, an increase in the volatility of returns to agricultural assets in this region decreases the certainty equivalence, and therefore, lowers the value of agricultural land in the region. This latent risk variable was also positive but insignificant in other two regions (Lake States, and Corn Belt regions.

5. Conclusion

Our results update MSS (2003) and extend the analysis to the state and region level. We used structural modeling framework with latent variables to investigate the impacts of risks in farm asset returns, and government payments, on the certainty equivalence of the farm lands in the United States. We found that an increase in the volatility of agricultural assets lowers the value of the certainty equivalence of agricultural assets, and hence the farm land values. This negative effect of the volatility of the expected return appears to be more pronounced in the Lake states, Corn Belt, and the Southeast regions. Model results also show that the interest rate plays major rule in the value of agricultural assets in the United States. In particular, we found that higher levels of interest rate lower the ratio of the imputed value to the market value of agricultural assets. We also found that government payments reduce the variability of agricultural returns and therefore increase the certainty equivalence of agricultural assets. In other words, government payments are offsetting the negative impacts of high volatility of the expected land returns. An evidence of this counter effect of the government payments was present in the Delta and Pacific regions.

Results of this paper are particularly relevant to the ongoing agricultural policy debate. More specifically, the government farm programs that reduce the variation of the return on the farmland will increase the value of agricultural assets even if commodity programs do not bring about an increase in mean returns.

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Table 1: Mean and Summary Statistics of the Variables used in the Study (1960-2004)

Region	**Real rate of Returns**	**Volatility in returns**	**Average interest rate**	$1/\theta$	**Average government payments per acre**
Northeast	-2.34	7.25	7.27	2.27	0.76
Lake states	-2.33	7.91	7.94	0.89	1.69
Corn Belt	-1.16	7.88	7.91	1.56	2.06
Northern Plains	0.06	8.05	8.09	2.60	1.25
Appalachia	-2.81	7.85	7.88	1.21	0.81
Southeast	1.20	7.95	7.99	2.12	1.15
Delta	0.94	8.24	8.28	2.28	2.20
Southern Plains	-2.17	8.01	8.04	1.15	0.87
Mountain	-1.47	7.79	7.81	1.22	0.38
Pacific	0.36	7.78	7.79	2.15	0.91
Region	-2.34	7.25	7.27	2.27	0.76

Table 2: Parameter Estimates of Measurement Model

Variable	Northeast	Lake States	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific
Return rate	1	1	1	1	1	1	1	1	1	1
	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
interest rate	1	1	1	1	1	1	1	1	1	1
	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Volatility$_t$	1	1	1	1	1	1	1	1	1	1
	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Volatility$_{t-1}$	1.010**	1.377**	0.744**	1.105**	1.131	1.218**	1.344**	1.057**	1.070**	1.166**
	(0.437)	(0.608)	(0.315)	(0.335)	(0.607)	(0.322)	(0.491)	(0.366)	(0.332)	(0.443)
Volatility$_{t-2}$	0.784**	1.064**	0.797**	0.629**	0.959	1.072**	0.904**	1.209**	1.009**	1.208**
	(0.391)	(0.522)	(0.323)	(0.266)	(0.557)	(0.272)	(0.396)	(0.394)	(0.322)	(0.452)
Government Paymemt	1	1	1	1	1	1	1	1	1	1
	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Chi-Square	5.001	11.728	4.979	7.703	7.813	4.361	7.180	8.921	6.243	3.906
Pr > Chi-Square	0.891	0.304	0.893	0.658	0.647	0.930	0.708	0.540	0.794	0.952
RMSEA	0	0.0634	0	0	0	0	0	0	0	0
AGFI	0.908	0.780	0.908	0.866	0.864	0.919	0.877	0.860	0.898	0.925
NNFI	0.949	0.861	0.942	0.917	0.891	1.197	0.925	0.921	0.945	0.958

Table 3: Parameter Estimates of the Structural Equation Model

Region	Northeast	Lake states	Corn Belt	Northern Plains	Appalachia	Southeast	Delta	Southern Plains	Mountain	Pacific
φ_1	0.368	0.547**	0.435**	1.405	0.250	0.414	0.258	0.255**	-0.281	0.176
	(1.517)	(0.133)	(0.124)	(2.690)	(0.157)	(0.205)	(0.321)	(0.086)	(0.987)	(0.175)
φ_2	-4.462	-0.501**	-0.297**	-1.128	-0.409**	-0.211	-1.464	-0.295**	-0.277	-0.553
	(15.447)	(0.142)	(0.123)	(1.961)	(0.115)	(0.252)	(1.988)	(0.086)	(0.300)	(0.337)
φ_3	-12.946	-0.409	1.083	-9.397	-0.539	2.342	-6.829	0.297	-4.064	-2.852
	(49.834)	(0.989)	(1.036)	(20.967)	(0.581)	(1.546)	(10.121)	(0.408)	(7.968)	(1.720)
φ_4	5.345	0.088	0.268	-10.996	-0.278	0.258	-0.634	0.601	-7.094	-1.070**
	(26.026)	(0.358)	(0.423)	(24.523)	(0.350)	(0.716)	(0.491)	(0.494)	(10.644)	(0.522)