Effect of Debt Solvency on Farmland Values: A Panel Cointegration Approach

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Abstract

Farmland values in the United States represent a major component of the farm sector balance sheet. The linkage between farmland values and agricultural debt has typically been ignored in the literature. This paper attempts to make two contributions to our understanding of farmland prices. First, building on established literature, this study examines the role of debt solvency and government payments in farmland valuation. Second, from a methodological standpoint, this study incorporates both the nonstationarity dimension of farmland prices and the panel structure of the data relying on recent advances in econometric literature.

Keywords: farmland values, pooling, debt-solvency, government payments, cointegration

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Farmland values in the United States represent a major component of the farm sector balance sheet. Farmland values accounted for an average of 68 percent of total U.S. agricultural assets between 1960 and 2002. 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 resource allocation inefficiencies. The significance of farmland values to the sector's economic performance has made factors determining farmland values a frequent subject of research in agricultural economics.

Research into farmland values has typically emphasized expected returns, interest rates, and government payments to farmers among other factors. However, the linkage between farmland values and agricultural debt has typically been ignored. This exclusion can primarily be attributed to the Modigliani-Miller (M-M) theorem, which states that asset values are independent of the financial means of ownership (debt or equity). However, the M-M results are based on arbitrage assumptions that may not be valid for agricultural asset markets. In this study we test the M-M proposition for farmland by examining whether the solvency of the agricultural sector affects farmland values. Hence, the evidence suggests that credit constraints decrease the value of farmland. This linkage between debt and farmland values in the agricultural sector also supports the existence of boom/bust cycles (Schmitz).

Building on established literature, this study examines the role of credit and government payments in farmland valuation. Particular attention is given to the role of credit constraints in this analysis. Following the model proposed by Shalit and Schmitz, invoking the M-M theorem, and Merton's options pricing model, we hypothesize that farmland values are affected by credit constraints. This hypothesis is consistent with the transaction cost hypothesis of Lence and Miller. Credit availability limits an investor's ability to buy and sell farmland. Thus, a short-run decline in farmland values may be magnified if credit is restricted. Farmers wanting to take advantage of a price decline in farmland may be prevented from doing so by changes in credit availability.

This study is different from others in several ways. First, it relates the farm investor's investment financing decision to the Modigliani-Miller theorem. Second, following Merton this study considers how default risk affects interest rates and farmland values. Finally, this study incorporates both the nonstationarity dimension of farmland values (first raised by Falk) and the panel structure of the data (state level panel data from 1960-2002) relying on recent advances in econometric literature.

Literature Review

Changes in farmland values have remained a frequent topic of interest in agricultural economics literature over the past four decades. This focus on farmland prices is related to the inherent instability in the farm sector and to several characteristics of farmland in particular. Lence and Miller noted that farmland accounts for a significant share of agricultural balance sheet assets. Changes in farmland values lead directly to significant changes in farm sector wealth (Schmitz).

Despite the importance of farmland values for the sector, empirical efforts to explain the fluctuations in land values have met with limited success. In general, studies that have attempted to explain land values using present value models have found that farmland values exhibit at least short-term price bubbles (Schmitz, Schmitz and Moss, Featherstone and Baker, Falk). Several studies have recently explained this behavior based on transaction cost models (Lence and Miller, Chavas and Thomas). Lence and Miller determine that changes in land values are typically bounded by transaction costs (brokerage fees) in the short run. Chavas and Thomas developed a dynamic model of farmland prices that includes non-additive dynamic preferences, risk aversion, and transaction costs. They find that both risk aversion and transaction costs have significant effects on land prices. Thus, empirical results classified by rational bubbles in the present value models may actually be the result of transaction costs. Additionally, the literature abounds with factors that have been linked to farmland prices including inflation (Moss; Feldstein), government payments (Tweeten and martin; Herdt and Cochrane; Clark et al.), capital gains (Melichar), net returns (Phipps; Burt; Alston; Featherstone and Baker; Falk), farm size, credit availability, input prices, risk, and taxes.

Credit is only one of the numerous variables possibly influencing farmland prices. In general finance, the Modigliani-Miller (M-M) theory expresses the relationship between asset values and the credit market. The proof of this proposition (M-M, proposition I) is based on the ability of either businesses or consumers to arbitrage equity for debt. Miller describes the basic insight as the fact that consumers ultimately own all the assets in the economy whether they are denominated in stocks (equity) or bonds (debt). Thus, the aggregate balance sheet remains unchanged as consumers decide the proportion of each to hold. Given this proposition, farmland values would be independent of the debt position in the farm sector. In general, objections have been raised to M-M invariance based on three concepts: dividend policy, bankruptcy, and taxes (Miller p. 102). The second of these objections may have significant consequences for agriculture. In addition, the invariance of financing from asset values in agriculture can be questioned on the basis of the arbitrage formulation. In general, new agricultural assets are purchased with either debt or retained earnings. The sector has not been successful in attracting external equity to the sector[1].

Farm credit influences asset values in several ways. First, debt influences profitability through interest costs. Second, debt influences liquidity through debt-servicing requirements (Barry, Baker, and Sanint). Barry, Baker, and Sanint note that credit reserves are themselves subject to risk, and therefore credit risk must be accounted for in the farmer's total portfolio risk, and in analysis of risk and liquidity management. Each of these components affects liquidity risk. Liquidity can be loosely defined as the ability of the borrower to meet cash obligations, as they are due. These cash obligations can be met in a variety of ways such as holding cash, inventories, or credit reserves. However, the use of credit reserves may also raise the question of the farm's liquidity risk. Liquidity risk is the risk that a solvent but illiquid borrower is unable to obtain

[1] The relationship between the rate of return on agricultural assets and other investments in risk pricing models (CAPM or the arbitrage pricing model) documents this fact. As mentioned in footnote 1, Barry finds a positive, statistically significant constant in his CAPM formulation. Similarly, Shiha and Chavas find that agricultural returns are segmented from returns on other assets. They conclude "…we are able to trace possible sources of segmentation to the existence of barriers to the flow of non-farm equity capital into farm real estate markets." (p. 405)

refinancing. In other words, it is the risk that your collateral will be worthless when you need it. Penson also notes the importance of farm debt and solvency measures in evaluating financial stress.

Hughes et al. employed a CAP model to examine subsidized credit offered by USDA and its impact on agriculture. They conclude that government subsidized credit likely increased farm real estate values, farmer's holding of financial assets, and farm debt. In their view it was highly unlikely that the rapid rise in farm real estate value during the 1970s should be attributed principally to the government intervention in farm credit markets, but likely was caused by other factors such as the rapid increase in farm exports. Credit availability could affect farmland markets. Therefore, it is important that farm credit markets are efficient. However, several studies suggest that credit constraints in the sector may be more binding than the sector's financial condition would demand. Farmers face funding constraints on short-term operating loans. If constraints exist, they will affect individual farm production decisions.

In the credit rationing literature, Stiglitz and Weiss present a model in which the interest rate fails to appropriately clear the credit market, leading to credit rationing. They develop two agents: a lender and a borrower. The "driving factor" within their proof is that the lender does not possess information about the borrower other than he/she was willing to borrow money at a stated interest rate. The authors show that as the interest rate rises, the good credit risk leaves the market and the financial intermediary is left with the bad credit risk. Thus, it may be in the bank's interest not to raise the interest rate, but to ration credit instead. Lee and Chambers, in an aggregate analysis, show that U.S. farmers experience credit constraints in financing variable production costs. Their work is an important component of a complete theory of lender behavior that recognizes that lenders may discriminate among borrowers. Innes (1990, 1991) examined imperfect information and information asymmetry as rationales for government intervention to address the impacts of information structures on credit markets.

Merton examined the risk structure of interest rates and how default risk affects interest rates and asset values. This formulation is consistent with Stiglitz's criticism of the M-M invariance proposition. Specifically, Merton derived the debt contract as a form of an option price. In this formulation, selling a corporate bond is identical to selling a European call option. Under Merton's framework, a corporation raises money by selling bonds that are secured by the corporation's assets. These bonds carry a fixed interest rate, but the return on the bonds is uncertain because of the possibility of bankruptcy. When the bonds mature, the corporation is left with the decision whether to pay off the bonds and keep the asset, or to default on the bonds and forfeit the corporation's assets to the bondholders. Based on this general framework, the interest rate charged by banks is an increasing function of the debt-to-asset ratio and an increasing function of the variance of the rate of return on corporate assets.

An Empirical Model of Farmland Values

Given these three strands of literature, this section develops a market model of farmland values based on the rental market. In order to incorporate the model of corporate debt as proposed by Merton into a farmland pricing model, we assume that the capital market between agriculture and the general economy does not allow for the infinite arbitrage of equity for debt. Any capital flowing into agriculture is then in the form of debt. Next, we assume that lenders price debt to agriculture based on their opportunity cost of capital and the bankruptcy risk within the option pricing formulation proposed by Merton. Given an increase in the relative risk of bankruptcy for agricultural assets, banks would charge a higher interest rate and the value of farmland would decline. Thus, a relative increase in agricultural debt without a corresponding increase in income implies an increase in bankruptcy risk, an increase in interest rate charged by banks, and a decline in agricultural asset prices. The measure of interest obligations relative to income used in this study is the debt-service ratio (Ryan and Morehart). The debt-service ratio is a liquidity ratio that measures the share of farm business gross income needed to service the debt. Under the option pricing model for debt, an increase in debt decreases liquidity because it increases the firm's debt-servicing requirements. Specifically, the debt-service ratio rises as interest expenses increase.

In our model, the rental price of farmland is based on the shadow value of farmland. The basic profit maximization problem facing the farm firm is to maximize profit subject to intermediate investments and land. Given that the shadow value of farmland is above the annualized market price of farmland, the producer chooses to purchase additional acres. Also, given our assumption regarding the capital market, we assume that purchase of farmland will be financed by issuing new debt (taking out a loan). The overall model of farm profit then becomes:

$$\begin{aligned} \max_{y,x,D,A,I} \pi &= py - wx - r(D,v)D + GP \\ st \quad & f(y,x,A,I) = 0 \\ & I \leq I_0 \\ & D = D_0 + (A_0 - A)v \end{aligned} \qquad (1)$$

where p is the vector of output prices, y is the vector of outputs, py is net of government payments, w is the vector of input prices, x is the vector of inputs, $r(D,v)$ is the interest rate paid on agricultural debt, D is the level of agricultural debt, GP represents a vector of government payments, v is the value of farmland, $f(y,x,A,I)$ is a technological envelope of production possibilities, I is the level of intermediate capital, I_0 is the fixed level of intermediate capital, D_0 is the level of initial debt, and A_0 is the initial land holding. This model is based on the notion that in long run equilibrium, farmland values will equal the discounted present value of future cash rents. In order to develop $r(D,v)$, we note that by the last constraint A_0, I_0 and D_0 along with the value of farmland determine initial wealth

$$E_0 = A_0 v + I_0 - D_0 \text{. (2)}$$

By the same concept, the value of equity for the current level of land and debt are determined by A, I_0, D and the value of land

$$E = Av + I_0 - D \text{. (3)}$$

Taken together equations 2 and 3 imply the capital constraint in equation 1 given that $E=E_0$ which must be true if we eliminate pure arbitrage (if we assume that the farmer cannot instantaneously make himself better off simply by purchasing farmland). Equation 3 also implies that the farm's debt to asset position can be written as

$$\delta(D, A, I_0, v) = \frac{D}{Av + I_0} \text{. (4)}$$

The debt to asset ratio is a decreasing function of farmland, farmland values, and intermediate investment, but an increasing function of debt. Within this expression, we know that A is a function of D and A_0 by the constraint in equation 1

$$A = A_0 + \frac{D - D_0}{v} \text{. (5)}$$

Thus, assuming that banks use option pricing to set the interest rate, this debt to asset position implies that the optimal interest rate charged by the bank is an increasing function of debt and a decreasing function of asset values (Merton). Given the maximization problem in equation 1, we form the Lagrangian:

$$L = py - wx - r(D,v)D - \mu_1(f(y,x,A,I)) + \mu_2(I_0 - I) + \mu_3(D - D_0 - (A_0 - A)v) + \mu_4(GP) \quad (6)$$

where μ_1 is the shadow value of the technological envelope, μ_2 is the shadow value of intermediate assets, μ_3 is the shadow value of new debt, and μ_4 is the shadow value of government payments. Focusing on the first order conditions with respect to land and debt yields:

$$\begin{aligned} \frac{\partial L}{\partial D} &= \frac{\partial r(D,v)}{\partial D}D + r(D,v) - \mu_3 = 0 \Rightarrow \mu_3 = \frac{\partial r(D,v)}{\partial D}D + r(D,v) \\ \frac{\partial L}{\partial A} &= -\mu_1 \frac{\partial f(y,x,A,I)}{\partial A} - \mu_3 v = 0 \end{aligned} \quad (7)$$

In order to simplify the formulation, first note that by definition of the shadow values

$$-\mu_1 \frac{\partial f(y,x,A,I)}{\partial A} = \frac{\partial \pi}{\partial A} \quad (8)$$

Next, we substitute the first condition in 7 into the second along with equation 8 to yield

$$\frac{\partial \pi}{\partial A} - \left(\frac{\partial r(D,v)}{\partial D}D + r(D,v)\right)v = 0 \quad (8)$$

Equation 8 yields an implicit form of the demand equation for rented farmland. Specifically, taking the marginal interest rate as fixed by the capital market, equation 8 determines the price of farmland that will clear the rental market. Alternatively, with some minor rearrangements of this expression yield the capitalization formula

$$v = \frac{\frac{\partial \pi}{\partial A}}{\frac{\partial r(D,v)}{\partial D} + r(D,v)}. \quad (9)$$

Assuming that agricultural interest rates are constant, equation 8 then yields the typical capitalization of future rents. This formulation is similar to the deterministic approach found in the literature (Schmitz; Lence and Miller; and Falk).

If we restrict the effect of additional debt on the interest rate to a multiplicative relationship, we can reformulate equation 9 as

$$v = \frac{\frac{\partial \pi}{\partial A}}{r\alpha(D)}, \quad (10)$$

$$\text{where } \frac{\partial \alpha(D)}{\partial D} > 0, \alpha(0) \geq r_f \quad (11)$$

where r_f is some risk free rate. Using Merton's work we can argue that the interest rate on debt is only a function of the required rate of return, r_f, and the probability of default or debt solvency.

Taking the natural logarithm difference of each side of equation 10 yields

$$d\ln(v_t) = d\ln\left(\frac{\partial \pi}{\partial A_t}\right) - d\ln(r_t) - d\ln(\alpha(D_t)). \quad (12)$$

Thus, to test for the importance of credit endogeneity, we can estimate

$$d\ln(v_t) = \beta_0 + \beta_1 d\ln(R_{At}) + \beta_2 d\ln(r_t) + \beta_3 d\ln(T_t) + \beta_4 d\ln(GP) \quad (13)$$

where R_A is the rate of return to farmland, r is the average interest rate on farm borrowing, T is a debt-servicing ratio[2] and GP represents government payments.

[2] Approximating $d\ln(v_t) = \ln(v_t) - \ln(v_{t-1})$ as in Moss. This allows for the inclusion of stochastic future revenues accruing over the asset's life.

Cointegration in Panel Data

The theoretical model presented in equation 13 can be estimated using a variety of procedures. However, since farmland values tend to be non-stationary (Falk 1991), regressions between non-stationary series may yield spurious results (Granger and Newbold 1974). Cointegration models based on Engle and Granger's (1987) seminal work have been developed to analyze possible long-run equilibrium between non-stationary variables. This study uses a recent innovation in the cointegration literature, namely estimation of panel data models. In particular, we will estimate the cointegrating relationship using panel data as described in Baltagi and Kao (2000). Panel data sets possess several advantages over conventional cross-sectional or time-series data sets (Hsiao, 2002). Our data set includes both cross-sectional (e.g., state-level) information as well as time-series information on farmland values, returns to farmland, interest rates, debt to asset ratios, and government payments. Based on the panel structure of the data, this study estimates the cointegrating relationship presented in equation 13 using Dynamic Ordinary Least Squares (DOLS) using NPT 1.3 (Kao and Chaing 2002).

In order to develop the cointegration framework used in this study, we start from the basic definition of a non-stationary variable. A variable is said to be non-stationary if its autoregressive coefficient is equal to one. Mathematically,

$$y_t = \phi y_{t-1} + \varepsilon_t \qquad (14)$$

where $\phi \to 1$. One straightforward extension of this basic formulation in panel data would be to extend this formulation to i states

$$y_{it} = \phi_i y_{i,t-1} + \varepsilon_{it}$$

(15)

where ϕ_i is the autogressive parameter for each state. Most panel approaches then assume that since $\phi_i \to 1$ for each state a panel test for non-stationarity in panel data would simply imply that $\phi_i \to \phi \to 1$ or that the pooled autoregressive coefficient would approach a common coefficient equal to one if the data were non-stationary. To make this conjecture more palatable, we follow the formulation of Harris and Tzavalis (1999) and allow for heterogeneous drift

$$y_{it} = \alpha_i + \phi y_{i,t-1} + \varepsilon_{it}$$

(16)

where α_i is the heterogeneous drift parameter.

Kao (1999) builds on this framework to develop a residual formulation for cointegration in panel data. Specifically, a long-run equilibrium (e.g., cointegrating) relationship exists in a time series if a stationary relationship exists between non-stationary series. Based on this definition, an empirical formulation of the long-run relationship can be derived as

$$\hat{e}_{it} = \rho \hat{e}_{i,t-1} + \nu_{it}$$
$$\hat{e}_{it} = y_{it} - x_{it}{}'\beta$$

(17)

where $y_{it} - x_{it}{}'$ depicts the estimated linear relationship between a panel of non-stationary variables (e.g., the cointegrating relationship is $[1 \quad -\beta']$), $\hat{e}_{it}$ is the estimated residual and ρ is the estimated autoregression coefficient for the linear relationship. Given this formulation if $\rho < 1$ then the residuals are stationary and a cointegrating relationship exists. Again note that β and ρ are pooled estimates.

To test for cointegrating relationships we first estimate β, ρ, and $\hat{e}_{it}$ using ordinary least squares and then compute the DF (Dickey-Fuller) tests for ρ. DF_{t_ρ} is a t-test for the autoregressive coefficient (Table 1). DF_ρ is a Dickey-Fuller test based on the assumption of strong exogeniety. Both DF^*_ρ and $DF^*_{t_\rho}$ allow for the possibility of endogenous regressors. Implicitly these procedures work best if N/T becomes large.

Data

We used U.S. Department of Agriculture, Economic Research Service state-level data for 46 states[3] (excluding Alaska, Hawaii, Pennsylvania and West Virginia), across 10 production regions from 1960 to 2002. These annual data on land values, interest rates, returns to farm assets, government payments, and debt servicing ratios 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. All prices and income are deflated using the implicit GDP deflator, 1992=100. Return to land is derived in a manner similar to Melichar. Net farm income was adjusted by subtracting imputed returns to operator labor and management. Average real interest rate is the average interest rate on farm business debt (i.e., ratio of interest expenses minus interest expenses associated with operators dwelling expenses to average 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.

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

Results

The standard asset pricing literature suggests that the estimated coefficients on the returns to farmland be one, the estimated coefficient on the real interest rate be negative one, and the estimated coefficients on the debt-to-asset ratio and government payments coefficient be zero. (The later results imply that Modigliani-Miller theorem of asset pricing holds and that income resulting from government transfers affects farmland values exactly likes income from the market). In general, the results depicted in table 2 indicate that the returns to farmland have a positive effect on farmland values and that farmland values decline with an increase in the real interest rate. Further, both the estimated coefficient on the debt-to-asset ratio and the share of government payments tend to be statistically significant for most regions indicating that the standard application of asset valuation models is insufficient to explain the long-run equilibrium between land values, returns to farmland, and real interest rates.

Focusing on the estimated effect of returns to farmland on real land values, the results indicate that this effect is positive and statistically significant at the 0.05 for the United States and nine of the individual regions. Curiously, the Cornbelt is the only region where the relationship between returns to farmland and farmland values is not significant at the 0.05 confidence level. This result is curious because this region is typically most closely identified with commercial agriculture in the United States. However, apart from the significant positive relationship between the rate of return to farmland and the real value of farmland, the estimated parameters are less than the anticipated values (e.g., we would anticipate the estimated parameter to be equal to one). One possible reason for a coefficient less than one may be the relative risk associated with agriculture. Specifically, using the certainty equivalence formulation of relative risk (Moss, Shonkwiler, and Schmitz 2003) the difference between the estimated coefficient and one could imply a risk premium. Under this interpretation agriculture in the Pacific States (e.g., California, Oregon, and Washington) is less risky than agriculture in the Lake States (e.g., Michigan, Minnesota, and Wisconsin). However, this interpretation is also dependent on the possible effect of the solvency of agriculture discussed below.

Turning to the results with respect to the real interest rate, the estimated effect of real interest rates on real asset prices are uniformly negative and statistically significant with the exception of the Pacific region. Again, the estimated results are consistent in sign and statistical significance, but the relative magnitudes of the estimated coefficients appear somewhat incongruous. Like the case of the coefficients on returns to farmland discussed above, this difference may be partially attributed to relative risk. For example, an alternative formulation to risk than the certainty equivalent approach is the risk adjusted discount rate approach (RADR). If the capital market for investment alternatives is in equilibrium, then the capital asset pricing model (Mossin, Sharpe, Lintner) implies that the rate of return on a more risky asset must be higher than the rate of return on a less risky asset. This equilibrium can be depicted as either an increase in the discount rate applied to the investment or a decrease in the certainty equivalence. Thus, estimated coefficients that are more negative than anticipated may simply imply a higher relative risk.

Alternatively, the difference between anticipated and theoretical results may be the result of measurement error in the real interest rate. In this application the real interest rate is computed as the natural logarithm of the nominal interest rate computed from the balance sheet and income statements less the logarithmic difference in the personal expenditure component of the implicit gross domestic product deflator. Setting aside the potential measurement error from our measure of inflation, the most probable source of measurement error comes from the use of the balance sheet and income statement to derive the nominal interest rate. Specifically, the appropriate discount rate for use in an asset-pricing model is a forward-looking marginal opportunity cost of capital. The balance sheet and income statement, on the other hand, yield a historical weighted average cost of capital. To the extent that this measure may understate the true forward-looking cost of capital, the potential measurement error introduced could cause the estimated coefficient to be more negative than anticipated.

Both of the results above, however, must be viewed within the context of the estimated coefficients on both the debt to asset level and the share of income received as government payments. As indicated above, in the strictest application of the asset-pricing model both of these factors should have no impact on farmland values. Under the Modglianni-Miller theorem, asset values are invariant to the way an asset is financed (i.e., whether an asset is purchased using debt capital or equity capital, the asset will have the same value). Similarly, source of the income should have no impact on its present value. The empirical results presented in table 2 indicate that both of these restrictions are rejected for the United States and a preponderance of regions. As depicted in table 2, increased debt to asset ratios result in lower farmland values in nine of the ten regions (with the Southeast as the only exception where the effect is positive, but not statistically significant). Further, the negative effect of the debt to asset ratio is statistically significant at the 0.10 confidence level in six of the nine regions (with the exceptions being the Delta

States, the Southern Plains, and the Pacific States). Further, the negative effect of the debt to asset ratio on farmland values is statistically significance at the 0.10 level of confidence in the Pacific region. Thus, we are left to conclude that farmland values do not conform to the Modigliani-Miller theorem, or that solvency of the agriculture sector affects the value of farmland. Further, increases in the debt to asset ratio (or decreases in the sector's solvency) cause farmland values to decline.

The results for the effect of the share of income derived from government payments are less striking. While the coefficient for the impact of the share of income from government payments on farmland values is negative and statistically significant at the 0.05 confidence level for the United States as a whole, the estimated coefficient is negative in only eight regions (with the exceptions being the Northeastern States and the Lake States) and statistically significant at the 0.05 confidence level in only six regions. Even more disturbing, the positive coefficient in the Northeast region is statistically significant at the 0.05 confidence level. Thus, the results suggest that for the United States as a whole (and for most of the regions within the United States) farmland values are a decreasing function of the share of income derived from government payments. This effect is consistent with the findings of Moss, Shonkwiler and Reynolds (1989) who found that increases in the share of income derived from government payments caused the change in farmland values to be lower over time.

Summary and Conclusions

This study examined whether farmland values in the United States were affected by changes in the sector's solvency. Our results indicate that decreases in the sector's solvency (measured as increases in the sector's debt to asset ratio) resulted in significantly lower farmland values. This result can be viewed in a variety of contexts. From an economic theory perspective, this result is contrary to Modigliani-Miller theorem that contends that the value of an asset does not depend on how that asset is financed. One possible explanation of the theoretical discrepancy is the lack of efficient debt/equity arbitrage in the farm sector in the United States.

The theoretical derivation of the Modigliani-Miller is based on arbitrage between stocks and bonds. Buying stocks and selling bonds or selling stock and buying bonds could rectify any undervaluation in the asset caused by financing. Historically, the farm sector in the United States has not been able to efficiently attract equity capital. Thus, the capital needs of the farm sector have largely been financed using debt. Hence, the value of farmland is determined by the cost of debt capital that may be priced using an option-pricing framework as depicted by Merton. Decreased sector solvency (measured as increased debt to asset ratios) could increase the marginal cost of capital leading to lower farmland values. We would argue that our model allows for this affect by recognizing that our real interest rate variable measures the average historical interest rate. Thus, our solvency variable provides information about the relative change in the marginal real interest rate over time. That is, decreases in the sector solvency lead to increases in the marginal real interest rate paid by agriculture.

From a policy perspective, our results indicate that changes in the sector's solvency may help explain the tendency of farmland values to exhibit boom/bust cycles as described by Schmitz and Featherstone and Moss.

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Table 1. Panel Test for Unit Roots

	Test Statistic	Critical Level
Land Values		
Without Intercept or Trend	0.6057	0.2724
With Intercept, Without Trend	0.1494	0.4406
With Intercept and Trend	-49.0217	0.0000
Returns to Farmland		
Without Intercept or Trend	-0.0043	0.4983
With Intercept, Without Trend	-15.7721	0.0000
With Intercept and Trend	-49.1745	0.0000
Real Interest Rate		
Without Intercept or Trend	-26.2386	0.0000
With Intercept, Without Trend	-6.9062	0.0000
With Intercept and Trend	-9.0243	0.0000
Debt Service Ratio		
Without Intercept or Trend	-0.1956	0.4225
With Intercept, Without Trend	-1.9238	0.0272
With Intercept and Trend	-44.8227	0.0000
Government Payments		
Without Intercept or Trend	-9.7385	0.0000
With Intercept, Without Trend	-14.9521	0.0000
With Intercept and Trend	-39.3887	0.0000

Source: Author's Computations Using NPT 1.3

Table 2. Estimated Cointegrating Vectors and Tests Statistics for Cointegration

	Cornbelt	Northeast	Lake States	Northen Plains	Appalachia	Southeast	Delta States	Southern Plains	Mountain States	Pacific States	United States
Returns to Farmland	0.0476	0.8097	0.2942	0.8004	0.4737	0.7803	0.4765	0.4082	0.7265	0.9289	0.6996
t-Ratio	0.4559	11.5395	2.0415	11.2063	4.2937	9.4142	6.9266	3.3969	10.2860	9.7905	19.8029
Prob(T)	0.3247	0.0000	0.0219	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000
Prob(N)	0.3242	0.0000	0.0206	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000
Real Interest Rates	-9.0428	-3.2344	-5.3704	-4.7531	-6.6520	-4.0355	-3.3521	-6.3841	-2.9738	-0.2782	-4.3291
t-Ratio	-5.9257	-3.3769	-2.6286	-5.0872	-5.1961	-4.9926	-3.5573	-5.3777	-3.2713	-0.3003	-10.2671
Prob(T)	0.0000	0.0004	0.0050	0.0000	0.0000	0.0000	0.0003	0.0000	0.0006	0.3823	0.0000
Prob(N)	0.0000	0.0004	0.0043	0.0000	0.0000	0.0000	0.0002	0.0000	0.0005	0.3820	0.0000
Debt to Asset Ratio	-0.0366	-0.0766	-0.0470	0.0153	-0.0310	0.0016	-0.0004	-0.0029	-0.0335	-0.0100	-0.0397
t-Ratio	-4.0928	-8.3217	-3.6087	2.1012	-2.2368	0.2921	-0.0569	-0.1742	-4.5128	-1.3715	-11.7303
Prob(T)	0.0000	0.0000	0.0002	0.0187	0.0133	0.3853	0.4774	0.4312	0.0000	0.0867	0.0000
Prob(N)	0.0000	0.0000	0.0002	0.0178	0.0126	0.3850	0.4773	0.4309	0.0000	0.0851	0.0000
Government Payments	-0.1131	4.0122	0.8444	-0.3585	-1.8784	-2.0001	-1.2701	-1.5415	-1.3641	-3.2113	-0.8205
t-Ratio	-0.2193	1.7213	0.7655	-1.0611	-1.5947	-3.6712	-2.9971	-2.4252	-2.0485	-5.0012	-3.3545
Prob(T)	0.4134	0.0430	0.2229	0.1453	0.0563	0.0002	0.0017	0.0092	0.0207	0.0000	0.0004
Prob(N)	0.4132	0.0426	0.2220	0.1443	0.0554	0.0001	0.0014	0.0077	0.0203	0.0000	0.0004
R-Squared	0.6535	0.6405	0.5026	0.8482	0.4399	0.7198	0.5796	0.7238	0.6831	1.0600	0.7273
R-Bar-Squared	0.5540	0.1030	0.2633	0.2651	0.3024	0.6098	0.2481	0.6579	0.3397	0.3414	0.0217

Source: Author's computations using NPT 1.3

Table 2. Estimated Cointegrating Vectors and Tests Statistics for Cointegration (Continued)

	Cornbelt	Northeast	Lake States	Northen Plains	Appalachia	Southeast	Delta States	Southern Plains	Mountain States	Pacific States	United States
DF_Rho	-0.7565	-2.1558	0.7116	-3.7442	-1.5745	-5.7206	-3.0375	-2.4369	-3.0735	-1.9262	-7.6297
Prob	0.2247	0.0156	0.2383	0.0001	0.0577	0.0000	0.0012	0.0074	0.0011	0.0270	0.0000
DF_t_Rho	1.0038	9.2175	2.4300	0.5526	2.9728	-0.0888	0.0151	-0.9722	4.9402	0.3226	44.5628
Prob	0.1577	0.0000	0.0075	0.2903	0.0015	0.4646	0.4940	0.1655	0.0000	0.3735	0.0000
DF_Rho_Star	-2.4758	-4.2386	-0.4274	-6.5157	-4.1417	-10.7386	-5.3844	-5.3781	-6.2639	-4.0296	-11.6744
Prob	0.0066	0.0000	0.3345	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DF_t_Rho_Star	-1.2105	-2.2804	-0.1417	-2.4905	-1.4884	-2.8687	-2.0155	-1.9189	-2.6697	-1.7590	-4.6146
Prob	0.1130	0.0113	0.4437	0.0064	0.0683	0.0021	0.0219	0.0275	0.0038	0.0393	0.0000

Source: Author's computations using NPT 1.3