



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Optimal capital structure and income support reform uncertainty

by

Carl J. Lagerkvist and Kent D. Olson^{*}

Abstract

This paper investigates the extent to which a major agricultural policy reform directed to the farm income influences the capital structure in an investing operation. In our model both the timing and the size of the anticipated reform are assumed to be unknown and stochastic. Closed form solutions for the implied restructuring prior to the reform is derived. Optimal pre-reform as well as post-reform leverage is estimated using the GMM technique on a balanced panel data set ranging over the years 1989-1998 based on Southwestern Minnesota Farm Business Management records. The empirical analyses the policy induced incentives for debt levels adjustment that may have prevailed prior to and after the 1996 Farm Bill. The empirical analysis strongly supports the theoretical analysis.

Keywords: Agricultural Finance, Investment, Uncertainty, Agricultural Policy

JEL Classification: Q12, Q14, D8, E2, H20, Q18

**Submitted for Presentation as a Selected Paper at the Annual Meeting of American Agricultural
Economics Association, July 28-31, 2002, Long Beach, California**

^{*} Lagerkvist is a Research associate in the Department of Economics, the Swedish University of Agricultural Sciences, P.O. Box 7013, SE-750 07 Sweden, e-mail: carl-johan.lagerkvist@ekon.slu.se. Olson is a Professor in the Department of Applied Economics, University of Minnesota. The authors initialized this paper while Lagerkvist visited the Department of Applied Economics at the University of Minnesota. He gratefully acknowledges the hospitality shown.

Introduction

Capital structure has proven to be a perennial puzzle in finance. This paper investigates the extent to which a major agricultural policy reform directed to the farm income influences the capital structure in an investing operation. The motivation for the analysis is the just closed round of Farm Bill negotiations, and the recent history of the 1996 Farm Bill, where a far reaching agricultural policy reform were preceded by prolonged negotiations, public debates and parliamentary processes. Such reforms often includes large, sporadic adjustment in support levels and the direction or the intended structure is often successively understood and anticipated by farmers. The political process, however, is usually set in a context that creates uncertainty about future support levels and noise about the precise timing of reform. Uncertainties about agricultural coupled income support levels is a relevant feature of the decision making process in the farm firm if future support payments influences today's investment, and the interdependent leverage decision.

Changes in agricultural policy are an additional source of risk and this type of uncertainty may affect farmers over an extended time-period but most of the existing capital structure literature assumes firms are concerned only with current period debt levels and risk (see for example Collins; Featherstone *et al.*). Existing nonmyopic models include the typical concept of variability of wealth and interest rates (Ramirez, Moss, Boggess), failure risk (Collins, Karp), and stochastic land prices (Lowenberger-DeBoer). Our approach provides a stand-alone contribution since, to our knowledge; no work has focused on the effects of dynamic policy (timing) uncertainty on the leverage decision by the farm operator.

In our model both the timing and the size of the anticipated reform are assumed to be unknown and stochastic. If the farmer continuously updates his information the dynamic stochastic adjustment problem can be transformed into a deterministic control problem linking

the optimal programs in the pre-reform and post-reform regimes. The technical advantage of the model is to allow for a separation between timing uncertainty and parameter uncertainty. Before the reform the solution rests on the conditional density of the timing and reform size, and by reversing the order of the involved integrals to again allow the use of standard control theory.

The generated model provides a measure of the restructuring of the capital structure by the wedge between the short-run (pre-reform) optimal debt level and the long-run debt level. Closed form solutions for the implied restructuring prior to the reform is derived. It is shown that the restructuring effect consists of two complementary mechanisms, a pure expectations effect and a timing uncertainty effect. Under uncertainty about future income support, three main results are derived. First, timing uncertainty reinforces the change in leverage motivated by expected changes in subsidy levels. Second, a mean preserving spread in expected post-reform subsidy levels decreases the leverage. And thirdly, the effect of a simultaneous mean preserving increase in the size and timing of the reform is ambiguous.

The empirical analysis is emphasized in the paper and analyzes the policy induced incentives for debt levels adjustment that may have prevailed prior to and after the 1996 Farm Bill. The data used to estimate the optimal capital structure decision and the incentives for debt adjustments is based on Southwestern Minnesota Farm Business Management records. The time series is represented in a balanced panel data set ranging over the years 1989-1998, and includes only sole proprietors. Optimal pre-reform as well as post-reform leverage is estimated using the GMM technique. The empirical analysis strongly supports the theoretical analysis.

Two alternative debt measures are included in the empirical application. The first is the conventional approach represented by the average total farm liabilities divided by the value of the capital stock. Since assets are reported at a fair market value we use the reported value of total farm assets as a measure of the value of the capital stock. This approach is in line with

models that try to provide predictions about the long-run equilibrium. MacKie-Mason and Graham, however, both report that problems associated with using a level specification arise when incentive effects (tax incentives) are to be estimated. Cumulative measures can lead to incorrect interpretations of the relationship between an incentive signaling variable and financial policy since the cumulative measures includes historical decisions not affected by the current incentive variable of interest. In the empirical analysis we therefore considers both the level specification and the change in total farm liabilities over the value of farm assets as a measure of the incremental debt use. To our knowledge the incremental approach has not been previously tested for agricultural firms.

The Model

This section develops a conceptual capital structure model for a farm operator out of an investment decision problem where the net receipts from the farm business is maximized subject to a binding dividend constraint derived from the budget constraint of the farm business. The farmer is informed that there will be an income support reform of coupled payments in the future and that the post-reform system is going to be in existence for a long time span.

It is assumed that the farm operator recognizes that the yield in any particular asset of the agricultural firm has to be the same as the yields of alternative investments outside the agricultural sector. The value of the farm operation is therefore

$$V_t = \int_{s=t}^{\infty} R_s e^{-\rho(s-t)} ds \quad (1)$$

where R_s denotes the net receipts from the farm business, $\rho = k(1 - \tau^e)$ denote the tax-adjusted opportunity rate of return on equity, and τ^e is the effective marginal tax rate on equity.

We follow Hubbard and Kashyap and do not account for risk aversion since future markets and or contracts are typically available to risk-averse farm operators.

Let t^* denote the date of the regime shift in public policy. The farm operator is assumed to have a well-defined and continuous probability density function (*pdf*) for the timing of the reform over the time interval between d and u given by $g:[d, u] \rightarrow \mathbb{R}_+$, with an associated continuous cumulative probability distribution function (*cdf*) $G:[d, u] \rightarrow [0,1]$. In addition, the farmer has formed beliefs of the size of the reform given by the *pdf* over the measure of agricultural direct support parameter interval $\gamma:[a, b] \rightarrow \mathbb{R}_+$ with a corresponding *cdf* Υ . We do not explicitly include dependencies between the timing of the reform and the size of change in the income support.

Prior to the reform ($t < t^*$), the farm operator faces the problem of determining the optimal investment policy to maximize the value of the productive enterprise, assuming he knows the form of its post-reform value for all possible realizations of γ and t^* . The dynamic stochastic adjustment problem is

$$V(K(t)) = \max_{I(t)} E_{t < t^*} \left[\int_t^{t^*} e^{-r(s-t)} R(s, \gamma) ds + E_{t < t^*} \left[e^{-r(t^*-t)} V(K(t^*)) \right] \right] \quad (2)$$

This stochastic problem is transformed into an ordinary deterministic control problem by the use of “a modified dynamic programming” technique following Alvarez, Kannianen and Södersten; Dasgupta and Heal. The farm operator maximizes (2) subject to three constraints.

The first is the dynamics for the aggregated capital stock K , with exponential decay at the rate δ we have that

$$\dot{K}_s = K_t e^{-\delta(s-t)} + \int_t^s e^{-\delta(s-y)} I(y) dy \quad (3)$$

The second constraint is the instantaneous budget constraint of the farm business. It is postulated that investments in the farm operation can be financed at the most by a combination

of retained earnings and net use of external funds. Net receipts are the residual after income taxes, payments to variable inputs, debt service, and net change in external funds and investment. Direct subsidies are introduced as dependent of agricultural prices and are tied to farm production decisions. This is a less stylized treatment of the FACT Act regime than the FAIR Act period but we motivate it from that LDP was related to product prices and that the AMTA (or PFC) transitory payments were based on pre-FAIR acreages and yields. Also, the price support for milk remained related to the product price in the FAIR period (USDA). Then (time and firm indices are not shown unless needed for clarity)

$$R = (1 - \tau) \{ (p + \gamma) F(K, L) - wL - zB - pc(I) \} + \dot{B} - (1 - \Gamma) P_K I_K \quad (4)$$

where τ is the marginal income tax rate, p is output price, w and L represents prices and quantities of costlessly adjustable inputs. z is the nominal cost of external funds. B is the amount of outstanding debt. $c(I)$ represent a strictly convex adjustment cost function. We model this adjustment cost as only dependent upon farm investment by analytical tractability. In the empirical part we have scaled this function to the capital stock to standardize the unit of measurement and to avoid spurious correlation results. \dot{B} is the net change in external funds. Γ is the present value of fiscal allowances per dollar of investment and P_K is the price of capital goods. Net receipts are not restricted to be non-negative.

The third constraint limits the use of external funds to a fraction h of the aggregate capital stock of the farm firm. Hence

$$B = h P_K K \quad (5)$$

It is common to constrain the share h over the interval $0 \leq h \leq 1$ (Lagerkvist; Jamarillio, Schianterelli and Wiess) or to impose a penalty interest rate if a upper limit of indebtedness is violated (Phimister). We do however leave this to the data.

To analyze the interlinked investment and financing decision consider first the post-reform regime (i.e. $t > t^*$). Here, γ_2 denotes the rate of income support in the post-reform regime. The value maximization is deterministic after the reform has been undertaken and the optimal control can therefore then be solved by ordinary techniques. By using (1)-(5), and assuming that the production function in (4) is linearly homogeneous and letting (F_K) denote the marginal product of the capital stock, the non-maximized value of the productive enterprise \hat{V} is given as

$$\hat{V}(K_s, I_s) = \left[\frac{(1-\tau)(p+\gamma_2)F_K}{\rho+\delta} - \frac{(1-\tau)zhP_K}{\rho+\delta} - \frac{h(\delta-\pi)P_K}{\rho+\delta} \right] K_s + \int_t^\infty e^{-\rho(s-t)} \left\{ \left[\frac{(1-\tau)(p+\gamma_2)F_K}{\rho+\delta} - \frac{(1-\tau)zhP_K}{\rho+\delta} - \frac{h(\delta-\pi)P_K}{\rho+\delta} - (1-h)P_K \right] I_s - (1-\tau)pc(I) \right\} ds \quad (6)$$

where $\pi = \dot{P}_K/P_K$ represents the rate of price inflation in the capital stock. The value of the productive enterprise consists of two parts. The first part originates from the current stock of capital employed and consists of the tax adjusted present value of the marginal revenue product (including the support payments per unit of capital), the net interest and the effective rate of debt repayment. The second (integral) part of the firm value is given by the present value of the cash flow from the future investment program. Post-reform optimal investment hence requires that

$$(1-\tau)pc'(I) = \frac{1}{\rho+\delta} \left[(1-\tau)(p+\gamma_2)F_K - (1-\tau)zhP_K - h(\delta-\pi)P_K \right] - (1-h)P_K \quad (7)$$

To obtain an operational investment equation we parameterize the adjustment cost function in (7) to $c(I) = \phi/2(I)^2$ and then solve for the debt to asset ratio. Then

$$h = \frac{\rho+\delta}{(\rho+\pi-(1-\tau)z)} + \frac{\phi(\rho+\delta)(1-\tau)pI}{(1-\Gamma)P_K(\rho+\pi-(1-\tau)z)} - \frac{(1-\tau)(p+\gamma_2)F_K}{(1-\Gamma)P_K(\rho+\pi-(1-\tau)z)} \quad (8)$$

Three parts thus define the optimal debt to asset ratio. The first term on the right hand side is the opportunity cost of a unit of capital weighted by the capital gains adjusted cost difference between equity and debt. The second term represents the marginal adjustment cost in installing new capital. This term is weighted with the relative price of capital goods and the cost difference between equity and debt. Finally, the third term represents the weighted marginal revenue product of capital.

The most striking contrast of (8) compared with the Collins framework is the postulated negative relation between debt and marginal revenue product of capital. Collins work and extensions made by Featherstone *et al*; Ramirez, Moss and Boggess, postulates that optimal leverage should be positively related to income augmenting agricultural policies and/or cash flow increases. Our result is a consequence of the investment activity and originates from the imposed budget constraint in which equity and debt are substitutes. Increases in internal funds, *ceteris paribus*, relax the constraint on debt financing.

Then consider the pre-reform regime (i.e. $t < t^*$) where uncertainty prevails with respect to the timing of the anticipated reform as well as with respect to the value of the support parameter in the post-reform regime. This regime is defined as the time elapsing from the disclosure of a planned reform to the actual implementation. Here, γ_1 denotes the rate of income support in the pre-reform regime. For any potential realization of t^* , the non-maximized value of the farm business is

$$V(K, t^*) = \int_t^{t^*} e^{-\rho(s-t)} \left\{ \left[1 - \tau \left[(p + \gamma_1) F_K K_s - zh P_K K_s - pc(I) \right] - h(\delta - \pi) P_K K_s - (1-h) P_K I_s \right] \right\} ds + e^{-\rho(t^*-t)} V^*(s) \quad (9)$$

where $V^*(s) = \sup_t V(K_s, I_s)$ from (6). Applying again (2) the solution to (9) is then obtained by linking the optimal programs in the pre-reform and the post-reform regimes, by

imposing that the farm operator gradually updates his information concerning the proposed policy reform according to the conditional density $P[t^* \in ds | t^* > t] = (g(s)ds / 1 - G(t)) \cdot 1_{[t, u]}(s)$, where $1_{[t, u]}(s)$ is the indicator function on the set $[t, u]$. Then using standard optimal control techniques gives that

$$(1-\tau)pc'(I) = \frac{1}{\rho+\delta} \left[(1-\tau)(p+\gamma_1)F_K - (1-\tau)zhP_K - h(\delta-\pi)P_K \right. \\ \left. + (E[(1-\tau)\gamma_2 F_K] - (1-\tau)\gamma_1 F_K) E_{t < t^*} \left[e^{-(\rho+\delta)(t^*-t)} \right] - (1-h)P_K \right] \quad (10)$$

so that with the same adjustment cost function as above we solve for the pre-reform optimal debt to asset ratio h and obtain

$$h = \frac{\rho+\delta}{(\rho+\pi-(1-\tau)z)} + \frac{\phi(\rho+\delta)(1-\tau)pI}{(1-\Gamma)P_K(\rho+\pi-(1-\tau)z)} - \frac{(1-\tau)(p+\gamma_1)F_K}{(1-\Gamma)P_K(\rho+\pi-(1-\tau)z)} \\ - \frac{\{E[(1-\tau)\gamma_2 F_K] - (1-\tau)\gamma_1 F_K\} E_{t < t^*} \left[e^{-(\rho+\delta)(t^*-t)} \right]}{(1-\Gamma)P_K(\rho+\pi-(1-\tau)z)} \quad (11)$$

where $E_{t < t^*} \left[e^{-(\rho+\delta)(t^*-t)} \right] = \int_t^u e^{-(\rho+\delta)(\omega-t)} \frac{g(\omega)}{1-G(t)} d\omega$ is the expected discount term.

Equation (11) is structurally identical to eq. (8) except for the last term. The last term captures the anticipatory optimal debt adjustment to a future farm policy reform of direct subsidies. The adjustment builds on two mechanisms, the expectation effect (related to subsidy levels) and the timing effect (uncertainty about the reform date). The pre-reform capital structure reveals the following properties with respect to income provision and timing uncertainty:

- (i) When $t < d$ a mean preserving spread in the changing time t^* increases h if

$$E[(1-\tau)\gamma_2 F_K] < (1-\tau)\gamma_1 F_K \text{ and decreases } h \text{ if } E[(1-\tau)\gamma_2 F_K] > (1-\tau)\gamma_1 F_K. \text{ Proof:}$$

the function $e^{-(\rho+\delta)(t^*-s)}$ is convex in t^* . Lemma 1 (p. 262) in Hartman and Jensen's

inequality imply that when $t < d$, a mean preserving spread in t^* increases the value of $E_{t < t^*} \left[e^{-(\rho+\delta)(t^*-t)} \right]$.

- (ii) When $d < t < u$, a mean preserving spread in γ_2 decreases h . Proof: let ε be a random variable and let $\gamma_2 + \varepsilon$ be a mean preserving spread of γ_2 satisfying the condition

$$E[\varepsilon | \gamma_2] = 0 \text{ then by using total probabilities and Jensen's inequality;}$$

$$E[(1-\tau)(\gamma_2 + \varepsilon)F_K] = \int_{[\gamma_2, \gamma_3]} E[(1-\tau)(\gamma_2 + \varepsilon)F_K] d\gamma[\gamma_2]$$

$$\geq \int_{[\gamma_2, \gamma_3]} E[(1-\tau)(\gamma_2 + \varepsilon) | \gamma_2] F_K d\gamma[\gamma_2]$$

$$\Rightarrow E[(1-\tau)(\gamma_2 + \varepsilon)F_K] \geq E[(1-\tau)\gamma_2 F_K]$$

- (iii) When $t < d$ the change in the debt to asset ratio originating from a simultaneous mean preserving increase in t^* and γ_2 is ambiguous if

$$E[(1-\tau)(\gamma_2 + \varepsilon)F_K] < (1-\tau)\gamma_1 F_K. \text{ Proof: let } \beta \text{ be a random variable and let } t^* + \beta \text{ be}$$

a mean preserving spread of t^* satisfying the condition $E[\beta | t^*] = 0$, and let ε be

defined as in (ii) then since

$$E[\exp(-(\rho+\delta)(t^* + \beta - t))] \{E[(1-\tau)(\gamma_2 + \varepsilon)F_K] - (1-\tau)\gamma_1 F_K\}$$

$$\leq E[\exp(-(\rho+\delta)(t^* - t))] \{E[(1-\tau)(\gamma_2 + \varepsilon)F_K] - (1-\tau)\gamma_1 F_K\}$$

and since

$$E[\exp(-(\rho+\delta)(t^* + \beta - t))] \{E[(1-\tau)(\gamma_2 + \varepsilon)F_K] - (1-\tau)\gamma_1 F_K\}$$

$$\geq E[\exp(-(\rho+\delta)(t^* + \beta - t))] \{E[(1-\tau)\gamma_2 F_K] - (1-\tau)\gamma_1 F_K\}$$

the effect on optimal debt use depends on the relative increase in the income support

as well as the relative increase in the reform date.

Data and construction of the variables

The data used to estimate the financial equations is based on Southwestern Minnesota Farm Business Management Association records. The time series initially collected covers the period 1989 through 1998 and includes 342 sole proprietors. Later years are not taken into consideration in order to not capture potential transitory adjustments due to the 2002 Farm Bill. The data were arranged in panel format. Since the data are analyzed in first differences using an instrumental method with time lags motivated that the shortest time period in the panel was set to four years following Arellano and Bond. We however also set a requirement that only farms with a full ten-year record should be selected in the panel to make the dynamic pattern in our data less subject to random variation. Such considerations left the final panel to be constructed out of observations from 76 farm operations with a total of 760 observations.

A review of the Southwestern Minnesota Farm Business Management Association by Andersson and Olson revealed that the farm data collected are not representative of all farms in the area. Major differences existed in total tillable acreage, total cash sales, total operating expenses, and net farm income. Although their study only compared data for 1987 it signals that the panel analyzed here can be subject to misrepresentations. We also recognize that such misrepresentations can be accentuated by only using data from farm operations with a full record of data over the period of interest.

A firm specific aggregated price index for capital goods was constructed out of indexes of prices paid by U.S. farmers for livestock, farm machinery, farm buildings, and production items collected from USDA. In addition, a farmland price index specific for the Southwestern Minnesota was collected from the Minnesota Agricultural Statistics Service. The aggregated farm specific price index was then constructed by weighting the price index for each good. The

share of ending capital values for each asset in total ending asset value represented the weights.

Assets valuations are based on a fair market value.

Following Withed we approximate the marginal product of capital with a cash flow variable and we consider two specifications of the cash flow. First, we include the firm's earnings before depreciation, interest and tax expenses, EBDIT. Second, we include the value of farm production (VFP) as an additional cash flow measure. VFP is gross farm income minus feeder livestock purchased and adjusted for inventory changes in crops, market livestock and breeding livestock. The major difference between the EBDIT and the VFP measure is therefore that the latter excludes cash expenses and that the former lacks the livestock and inventory adjustments.

The Farm Management Association registers government payments to farm operators in three codes: a) deficiency payments (in old policy) and PFC together with AMTA and LDP payments; b) CRP payments; and c) Other government payments. There is however, according to our information a belief that the records are to some extent mixed with respect to parts a) and c). In our specification of the income support we therefore considers two alternatives. The first is given by code a) and the second aggregates codes a) and c). In order to normalize the unit of measurement and to avoid problems of heteroscedasticity the net of tax government payments in each specification is deflated by the beginning value of total farm assets.

The Data Appendix provides a further detailed description of the other variables used in the empirical analysis. Figure 1 depicts the time pattern of the major variables included in the empirical analysis and Figure 2 reveals the standard deviation for each variable.

The average debt to asset ratios was approximately 0.45 during 1989-1992, but in the 1993-1998 period only around 0.35. It is also apparent that farmers become more homogeneous with respect to the level of debt in the subsequent period. The VFP and the EBDIT measures of

cash flows reveals similar patterns of development and there is a relatively close correspondence in time between the cash flow measures and the debt to asset ratio. Comparing the total debt specification of the debt to asset ratio with the alternative annual change measure indicates that there seems to be a case where some farm operators have made substantial increases in debt use when others reduced their debt use since both the average and the variation in the debt change in some years has the opposed direction as compared to the level specification. The time pattern of government payments as a share of the total assets is also exhibiting a close connection to the time patterns of the debt measures. For the period 1989-1993 the average $GVPT1/A$ is 2.6 percentages while only 1.3 percentages in the 1994-1998 period. Similarly, the average $GVPT2/A$ is 3.1 percentages in the 1989-1993 period but only 2.2 percentages in the later period.

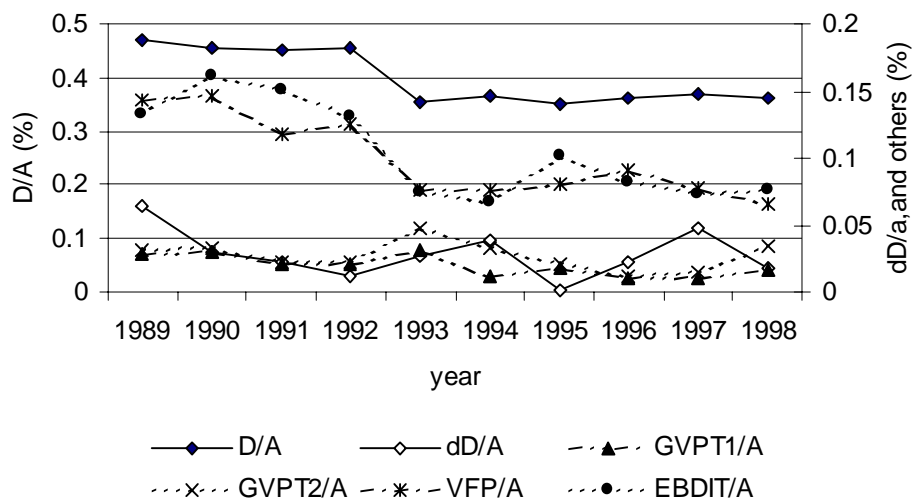


Figure 1. Average values for Debt to Asset ratios (D/A), annual change in use of debt divided with total farm assets (dD/A), Government Payments divided by total farm assets (GVPT1/A), Total Government Payments divided by total farm assets (GVPT2/A), Value of Farm Production divided by total farm assets (VFP/A), and EBDIT divided by total farm assets (EBDIT/A) for 76 sole proprietorships in Southwestern Minnesota 1989-1998.

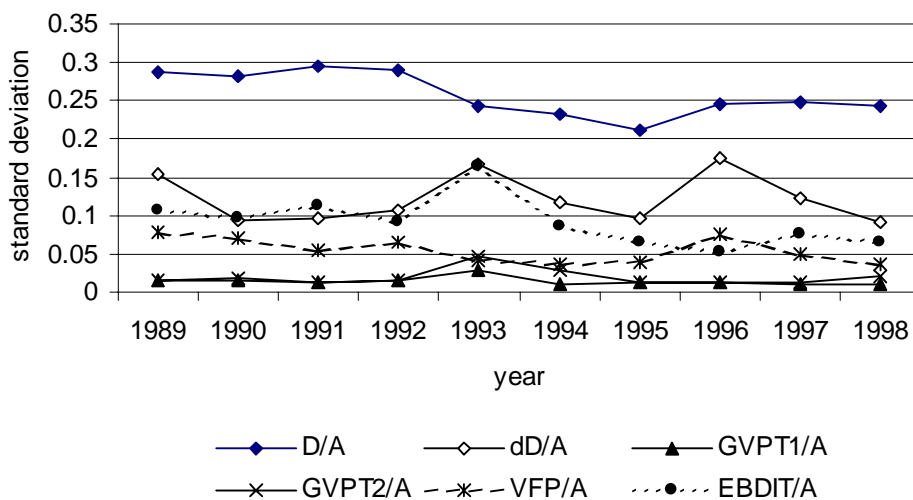


Figure 2. Standard deviations for Debt to Asset ratios (D/A), annual change in use of debt divided with total farm assets (dD/A), Government Payments divided by total farm assets (GVPT1/A), Total Government Payments divided by total farm assets (GVPT2/A), Value of Farm Production divided by total farm assets (VFP/A), and EBDIT divided by total farm assets (EBDIT/A) for 76 sole proprietorships in Southwestern Minnesota 1989-1998.

Econometric Specification and Results

The financial models (8) and (11) require estimation by the Generalized Methods of Moments estimator developed by Hansen and Singleton: Arellano and Bond. This is motivated by the non-linearities in the financial equations and also since appropriately lagged instruments for endogenous explanatory variables are required. By construction of data and by assumption, all right-hand side values in (8) and (11) is endogenous in the sense that they are determined at the level of the farm. The results are generated using Ox version 2.20 (Doornik, 1999) and the DPD package version 1.00 (Doornik, Arellano and Bond, 1999).

In order to eliminate the firm-specific effect estimations are done in first-differences and then lagged instruments is used to fulfill the orthogonality requirement. Since instruments are selected out of lagged dependent variables with further lags on the same variables the assumption of no serial correlation in the error term is vital for the consistency of the estimators. The existence of serial correlation is tested for and if the error term is not serially correlated there should be evidence (with a negative sign) for first-order serial correlation but no evidence for second-order correlation in the first-differenced residuals (Arellano and Bond 1998). In addition, the Sargan test for over-identifying restrictions is calculated. This performs a joint test of the model specification and the validity of the instruments (i.e. it tests if the moments are fulfilled) under the desirable null hypothesis that the over identifying restrictions hold. The Sargan test is chi-square distributed with as many degrees of freedom as over identifying restrictions.

The Wald test reported is a test for the joint significance of the regressors and a separate Wald test is reported when time effects are included to reveal the significance of time dynamics. The Wald tests are also chi-square distributed with as many degrees of freedom as variables tested.

Econometric Results

We first estimated the post-reform financial model (8) over the whole sample to obtain a long-term relationship. In addition, we estimated (8) both in the level specification and in the annual change in the level of total farm liabilities as the dependent variable. The empirical specification applied is

$$y = \beta_1 X_1 + \phi X_2 - \beta_2 X_3 + f + t \quad (12)$$

where y is depending on the choice of specification either $y_1 = D/A$, or $y_2 = \Delta(D)/A$, and

$$X_1 = \frac{\rho + \delta}{(\rho + \pi - (1 - \tau)z)}, \quad X_2 = \frac{(\rho + \delta)(1 - \tau)pI/A}{(1 - \Gamma)P_K(\rho + \pi - (1 - \tau)z)}, \quad X_3 = \frac{(1 - \tau)(p + \gamma_2)}{(1 - \Gamma)P_K(\rho + \pi - (1 - \tau)z)} \cdot \frac{\Phi}{A}.$$

The variable Φ is either Value of farm production or EBDIT. f and t represents fixed effects and time effects, respectively. ϕ is the quadratic adjustment cost parameter.

Table 1 shows the result for estimating various versions of (12). Estimation was carried out by the two-step DPD procedure. The set of instruments includes the dependent variable, the regressors as well as the marginal tax rate, the opportunity cost of equity and the effective income tax adjusted debt interest rate. All instruments are lagged two and three periods. Both the total debt specification and the incremental debt use specification are estimated with appropriate signs and no specification is rejected by the Sargan test. The Sargan test is more in support of the annual change specification than the total liability specification when the value of farm production is chosen as a proxy for cash flow but only slightly in favor the incremental specification when EBDIT is used as a cash flow proxy. We recognize that this difference may be due to a short-run cash flow identity relation between the annual change in farm liabilities and the cash flow. Caution is therefore warranted before drawing any long-run implications for the debt policy from the annual change approach. The negative signs of the cash flow variables are, however, also consistent with the Myers & Majluf agency-theoretic pecking-order hypothesis in

the corporate finance literature where internal funds are preferred to external funds if the former type is available since it is viewed as less costly.

Table 1. First-difference estimates of long-term financial relation (12), (sample period 1989-1998)

	D/A (VFP)	D/A (EBDIT)	$\Delta(D)/A$ (VFP)	$\Delta(D)/A$ (EBDIT)
β_1	0.0009	0.001	0.0021	0.001
(p-value)	(0.068)	(0.000)	(0.000)	(0.000)
ϕ	0.027	0.0424	0.057	0.081
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
β_2	-0.002	-0.0062	-0.0011	-0.0127
(p-value)	(0.425)	(0.000)	(0.000)	(0.000)
W(joint)	1828.0	930.0	3594.0	6003.0
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
W (time)	2052	4522	$1.075 \cdot 10^4$	555.7
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Sargan	67.99	70.08	63.76	69.77
(p-value)	(0.409)	(0.342)	(0.555)	(0.352)
AR(1)	-2.668	-2.149	-3.849	-3.111
(p-value)	(0.008)	(0.032)	(0.000)	(0.002)
AR(2)	-0.633	-0.943	-1.216	-1.518
(p-value)	(0.527)	(0.346)	(0.224)	(0.129)

Notes: W (joint) - Wald test of joint significance of regressors. W (time)- test of joint significance of time dummies. Sargan - test of overidentifying restrictions and model specification. AR(1) and AR(2) - tests for first (1) and second (2) order correlation in the residuals.

Contrast to the total debt specification using the value of farm production the cash flow variable in the total debt specification using the EBDIT measure is significant. This result is important in relation to the recent work by Gomes on corporate firms (the Compustat data set). Gomes reports that cash flow adds some predictive power to investment equations even in absence of financial friction but he assigns the explanation of this finding to measurement and specification errors. Gomes approximate the marginal product of capital with a cash flow variable defined as the sum of operating income and depreciation. Although none of our cash flow variables are identically defined as the variable used by Gomes, it seems likely that the

value of farm production is more close to his definition than the EBDIT measure. The strong support for the EBDIT measure is therefore an important result since it is obtained without imposing any financial constraints and also since our model is fully specified. Jensen and Langemeir using a Tobit model found for Kansas farms support for a positive relation between the total debt to asset ratio and firm profitability (operating income before depreciation, interest and taxes) during 1973-1981 but no significance during 1982-1988. The study by Jensen, Lawson and Langemeir provides additional support for internal cash flow in agricultural investment models using a cash flow variable equal to ours, except for inflation adjustment, but their result is obtained by OLS-estimation.

For all cases represented in Table 1 the estimated values of the adjustment cost parameter is highly significant and low but fairly reasonable. The recent study by Lagerkvist & Olson, which is based on the complete South Western Minnesota Farm Association data set over the same time period as here (and which uses a more detailed specification of the adjustment cost function), reports an adjustment cost around 2.4% of investment expenditures. The higher adjustment cost parameter reported for the annual change specifications probably indicates that earlier approaches may have underestimated the appropriate size of these costs. This is likely due to an averaging effect that appears when annual investment is associated with total liabilities; this averaging is obviously absent in the annual change specification.

The Wald statistics for included time dummy variables are highly significant for all cases represented in Table 1. Actual estimates are not shown due to space limitations but the single most notable results in the total debt models are found for 1993; estimates are -0.1113 and -0.119 for the VFP and EBDIT model, respectively. This is clearly related to the illustration in Figure 1. In the annual change models the largest values is found for 1995 and 1998 reveals; around -0.033 for the VFP model and around -0.026 for the EBDIT specification. The total

debt model with the EBDIT measure reveals a stronger time dependency than the VFP model. The reverse, however, holds for the annual change models. The reported value of the Wald test for time dummy variables in the annual change model using the VFP measure is extremely high.

Simulation of anticipatory adjustment effects prior to the reform

In this section we provide the results from the estimation of the pre-reform leverage equation (11) including the anticipatory optimal debt adjustment to a future farm policy reform of direct subsidies. The farm operator faces in the pre-reform period uncertainty about both the magnitude of the expected reform and uncertainty about the actual reform date. After the longest farm bill debate in U.S. history, the FAIR Act became law in 1996. According to Gardner it became apparent in 1994 that less government spending was a political priority.

Our strategy here is to simulate the expected post-reform level of income support as well as the expected reform date. Firm specific simulations were performed using the @Risk ver. 4 software from Palisade Inc. We then include the simulated results into the estimation of (11). The chosen approach will be open to criticism for incorporating *ad hoc* assumptions into the analysis. It is recognized that the only strictly valid approach would have been to directly question all farm operators represented in the panel about their subjective beliefs and out of such information make appropriate simulations. For obvious reason that was not accomplishable. An alternative would have been to use realized future values of the income support payments as proxies for the operator's expectations about future payments. In a related work on expectations Moss, Shonkwiler and Ford estimated future rate of returns values with an ARCH model.

The individual expectation about the expected value of the post-reform income support were obtained from the assumption that each farm operator expected his average income support cut by one half through the reform and that direct payments were to be gradually

decreasing over time. Our strategy in assessing the size of the expected change in support levels is based on the observed differences between the pre-FAIR and the post-FAIR regimes illustrated in Figure 1. To add uncertainty around a declining trend a normal, firm and year specific, *pdf* with the mean equal to 0.5 times a moving average of historical direct support levels, and the standard deviation set equal to the historical standard deviation up to the specific year was simulated. In order to reduce the range of simulated post-reform subsidies each *pdf* was truncated to be at least 0.25 times the historical given support and at maximum be equal to the historical average of support payments received.

The individual expected reform date was simulated under a general Beta distribution. The earliest reform date was set to 1994, the latest to 1997 and the modal value was also set to 1996.

We estimated (11) both in the total debt to asset specification and in the change specification. The empirical specification applied is

$$y = \beta_1 X_1 + \phi X_2 - \beta_2 X_3 - \beta_3 X_4 + f + t \quad (13)$$

where y is depending on the choice of specification either $y_1 = D/A$, or $y_2 = \Delta(D)/A$, and

$$X_1 = \frac{\rho + \delta}{(\rho + \pi - (1 - \tau)z)}, \quad X_2 = \frac{(\rho + \delta)(1 - \tau)pI/A}{(1 - \Gamma)P_K(\rho + \pi - (1 - \tau)z)}, \quad X_3 = \frac{(1 - \tau)(\rho + \gamma_2)}{(1 - \Gamma)P_K(\rho + \pi - (1 - \tau)z)} \cdot \frac{\Phi}{A}.$$

$$X_4 = \frac{\left\{ \dot{E} \left[(1 - \tau) \gamma_2 F(\cdot) \right] - (1 - \tau) \gamma_1 F(\cdot) \right\} E_{t < t^*} \left[e^{-(\rho + \delta)(t^* - t)} \right]}{(1 - \Gamma)P_K(\rho + \pi - (1 - \tau)z)}$$

The variable Φ is either Value of Farm Production or EBDIT. f and t represents fixed effects and time effects, respectively. ϕ is the quadratic adjustment cost parameter.

Table 2 shows the result for estimating various versions of (13). Estimation was carried out by the two-step DPD procedure. The set of instruments includes the dependent variable, the

regressors as well as the marginal tax rate, the opportunity cost of equity and the effective interest rate. All variables were lagged two and three periods.

Table 2. First-difference estimates of pre-reform financial relation (13), (sample period 1990-1996)

	D/A (VFP)	D/A (EBDIT)	$\Delta(D)/A$ (VFP)	$\Delta(D)/A$ (EBDIT)
β_1	0.0002	0.0009	0.00174	-0.0008
(p-value)	(0.841)	(0.000)	(0.042)	(0.104)
ϕ	0.028	0.0385	0.056	0.062
(p-value)	(0.000)	(0.01)	(0.000)	(0.000)
β_2	0.0001	-0.0063	-0.00086	-0.0015
(p-value)	(0.809)	(0.000)	(0.017)	(0.56)
β_3	0.041	0.029	0.028	0.035
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
W (joint)	135.8	176.1	272.4	212.2
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
W (time)	373.4	297.8	38.5	28.67
(p-value)	(0.000)	(0.000)	(0.000)	(0.000)
Sargan	59.83	54.12	46.88	46.94
(p-value)	(0.099)	(0.221)	(0.477)	(0.475)
AR(1)	-2.376	-2.417	-3.397	-3.415
(p-value)	(0.018)	(0.000)	(0.001)	(0.001)
AR(2)	-1.057	-1.364	-1.227	-1.265
(p-value)	(0.291)	(0.173)	(0.22)	(0.206)

Notes: W (joint) - Wald test of joint significance of regressors. W (time)- test of joint significance of time dummies. Sargan - test of overidentifying restrictions and model specification. AR(1) and AR(2) - tests for first (1) and second (2) order correlation in the residuals.

Table 2 reveals that there exists higher support for the annual debt change specification as compared to the total debt specification. Both the Wald (joint) test as well as the Sargan statistics is in large favor of the incremental approach. This is an encouraging result that supports earlier findings by MacKie-Mason and Graham on tax incentives.

In contrast to the long-run estimation the cash flow variable is not significant in the pre-reform annual change specification when the EBDIT measure is used as a proxy for the marginal

product of capital. The same holds for the adjusted opportunity cost of capital variable (β_1), which is also reported with a negative sign.

The adjustment cost variable is found to be stable in relation to the results revealed in Table 1.

Moreover, our estimations strongly support the existence of adjustments in the debt use associated by expected changes in the agricultural income support payments. The β_3 -variable is positive, which is in accordance with the theoretical prediction when income support payments are expected to decrease after a reform.

We performed three tests to control for the sensitivity in our result to the assumed timing of the reform as well as the scope of the reform. In each test the individual support payment or the reform date distributions were re-simulated under alternative assumptions. The first test invoked a mean preserving spread in the reform date distribution. The standard deviation was increased from 0.224 to 0.488 in the normalized Beta function. The second test was used to analyze the effect of extreme reform time expectations. Each farmer was assumed to expect the reform in 1996, and to have a skewed *pdf* around that year (with a standard deviation of 1/6). Finally, the third test was used to analyze the sensitivity with respect to the size of the expected change in income support. Here a normal *pdf* with the mean equal to 0.85 times a moving average of historical income support levels, and the standard deviation set equal to the historical standard deviation up to the specific year was re-simulated. We also now truncated the *pdf* for the expected post-reform value to be at least 0.5 times the historical given support and at maximum be equal to the historical average of support payments received.

The main findings in our sensitivity analysis are as follows. A mean preserving spread in reform date density functions fits the data better. The estimated β_3 -parameters is reported with

slightly higher values, which is in accordance with the theoretical result. The p -values in the Sargan tests are higher, irrespectively of model specification, and the Wald (joint) test reveals higher test statistics in absolute values. This may be indicative of that farmers had widely dispersed beliefs about the reform date. Also, the Wald tests for time dummies are stronger for the annual change specifications and remain almost constant for the total debt specifications. The second test on extreme expectations about the reform date produced higher Sargan statistics for the total debt specifications and lower test statistics for the annual change specifications. Also, the time dummy variables were less supported in this test. Finally, reducing the expected change in the income support payments along with a narrowing of the possible range of outcomes generated weaker Sargan statistics and slightly lower β_3 -parameter values.

Conclusions

This paper develops and tests a novel stochastic model of optimal leverage in the agricultural firm under uncertainty of future direct subsidies in an expected policy reform. Farm income has been at focus in most farm policies. Income-augmenting and/or risk-reducing policy provisions have been, and probably will continue to be, the core in reaching the policy objectives vis-à-vis the farm operators. Although reforms of agricultural income provisions may be large and appear sporadically they are seldom not foreseen by the farmers. The political process, however, contributes to uncertainty around the actual outcome of the changes in policy provisions, and also to uncertainties about when in time policies will change. The existence of timing uncertainty required the analysis reach beyond the work by Ricardo. Closed form solutions for the implied leverage adjustment prior to a reform are provided by the wedge between the short-run (pre-reform) optimal leverage and the long-run optimal leverage.

The model was tested on a dynamic balanced panel of micro data using the 1996 Farm Bill as analytical subject. The empirical analysis strongly supports the theoretical model developed and also supports that in studying the adjustment in the capital structure related to the investment decision the analysis can benefit from using an annual change specification of the leverage measure. We have also found that cash flow measures are relevant in farm leverage models but that the significance of cash flow as an explanatory variable depends on its measurement and the model specification.

The policy implications of the results obtained are potentially important because farm financial structure is a potentially significant determinant of the variability of farm income. The results emerging from this study shows the existence of anticipatory adjustments in capital structure by the announcement of agricultural programs linked to the farm income or variability in income. An increase in the noise around the outcome of a policy reform directed towards the income of farmers has surprisingly volatile and ambiguous effects on farm debt. Lack of information creates incentives for a potentially inefficient capital structure and this inefficiency is reinforced by timing uncertainty, which makes the farm operator more likely to misapprehend the reform date.

Future research is warranted on this issue, especially in incorporating the effects of risk aversion of the farm operators to the model developed. Risk attitudes was considered in an early stage of this paper but not incorporated since it is not clear if there exists an analytical solution. Also, future work is warranted on the discrepancies between the optimal leverage as implied by our model and the actual levels of leverage observed for the farm firms included in the data set.

References

- Ahrendsen, B. L., Colleander, R. N. and B. L. Dixon. "An empirical analysis of optimal farm capital structure decisions." *Agricultural Finance Review* 54 (1994):108-119.
- Alvarez, L. H. R., V. Kanninen and J. Södersten. "Tax policy uncertainty and corporate investment - A theory of tax-induced investment spurts". *Journal of Public Economics* 69 (1998):17-48.
- Andersson, H. and K. D. Olson. "On comparing farm record association members to the farm population." *Review of Agricultural Economics* 18 (1996):259-264.
- Arellano, M. and S. Bond. "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations." *Review of Economic Studies* 58 (1991):277-297.
- Arellano, M. and S. Bond. (1998). "Dynamic panel data estimation using DPD98 for GAUSS: A guide for users."
- Collins, R. A. "Expected Utility, Debt-Equity Structure, and Risk Balancing." *Amer. J. Agr. Econ.* (August 1985) pp.627-629.
- Collins, R. A., and L. S. Karp. "Lifetime Leverage Choice for Proprietary Farmers in a Dynamic Stochastic Environment." *Journal of Agricultural and Resource Economics*, 18(2):225-238.
- Doornik, J.A. (1999), Object-Oriented Matrix Programming Using Ox, 3rd ed. London: Timberlake Consultants Press and Oxford: www.nuff.ox.ac.uk/Users/Doornik.
- Doornik, J. A., Arellano, M. and S. Bond. (1999). Panel Data estimation using DPD for Ox. www.nuff.ox.ac.uk/Users/Do.
- Featherstone, A. M., Moss, C. B., Baker, T. G. and P. V. Preckel. "The Theoretical Effects of Farm Policies on Optimal Leverage and the Probability of Equity Losses". *Amer. J. Agr. Econ.* (August 1988) pp.572-579.
- Gardner, B.L. "Agricultural economics in the policy arena". *Review of Agricultural Economics* (1996) 18:155-165.
- Gomes, J. F. (2001). "Financing Investment". *American Economic Review*, December 2001, 91(5), pp.1263-1285.
- Graham, J.R. Debt and the marginal tax rate, *Journal of Financial Economics* (1996) 41:41-73.
- Hartman, R. "The Effects of Price and Cost Uncertainty on Investment". *Journal of Economic Theory* (1972), pp:258-266.
- Hubbard, R. G. and A. K. Kashyap. "Internal net worth and the investment process: an application to U. S. Agriculture." *Journal of Political Economy* vol. 100 no. 3 (1992):506-534.
- Jaramillo, F., Schiantarelli, F. and A. Weiss. "Capital market imperfections before and after financial liberalization: An Euler equation approach to panel data for Ecuadorian firms." *Journal of Development Economics* vol. 51 (1996):367-386.
- Jensen, F. E., Lawson, J.S. and L. N. Langemeir. "Agricultural investment and internal cash flow variables." *Review of Agricultural Economics* vol. 15 (2) (May 1993):295-306.
- Jensen, F. E. and L. N. Langemeir. "Optimal Leverage with Risk Aversion: Empirical Evidence". *Agricultural Finance Review* 56 (1996):85-97.
- Lagerkvist, C. J. and K. D. Olson. "Asymmetric information, capital structure and agricultural investment". Paper presented at the Annual Meeting of the American Agricultural Economics Association, Chicago, August 5-8, 2001.

- Lowenberg-DeBoer, J. *The Microeconomic Roots of the Farm Crisis*. New York: Praeger Press, 1988.
- MacKie-Mason, J. "Do taxes affect corporate financing decisions?", *Journal of Finance* (1990), 45:1471-1493.
- Myers, S. C. and Majluf, N. S. "Corporate Financing and Investment Decision When Firms Have Information that Investors Do Not Have". *Journal of Financial Economics*, June 1984, 13(2), pp.187-221.
- Phimister, E. "The impact of borrowing constraints on farm households: A life-cycle approach." *European Review of Agricultural Economics* 22 (1995):61-86.
- Ramirez, O., Moss, C. B., and W. G. Boggess. "A Stochastic Optimal Control Formulation of the Consumption/Debt Decision". *Agricultural Finance Review* 57 (1997):29-38.
- USDA. "1996 FAIR Act Frames Farm Policy For 7 Years". Agricultural Outlook Supplement. April 1996. Economic Research Service.
- Whithed, T. M. "Debt, liquidity constraints and corporate investment: evidence from panel data". *The Journal of Finance* 1992 (4):1425-1460.

Data Appendix

Variable	Description
$I_{i,s}$	Gross investment. Includes purchases of breeding livestock, machinery and farm equipment, other interim assets, farm buildings, farmland, and other long-term farm assets. Includes changes in inventories for livestock and crop and feed.
B_s	Book value of total farm liabilities.
z_s	Effective interest rate on debt. Defined as cash interest expenses divided by the annual average of the book value of beginning total liabilities, ending total liabilities and borrowed current liabilities.
K_s	Value of total farm assets at fair market values.
ρ	Opportunity rate of return on equity. Based on 10-year Treasury Constant Maturity Bonds. Moving 5-year average of annual yields calculated by weighting monthly data. Data obtained from www.econmagic.com .
τ_s	Marginal tax rates on farm income. Includes federal income tax, self-employment tax and state income tax. Calculated for each firm and year.
τ^e	Effective marginal tax rate on equity. Calculated for each firm and year as the alternative tax obligation obtained by multiplying farm net worth by the market portfolio return.
Γ_s	Present value of fiscal allowances. Calculated for each firm and year as a weighted index, using share of purchased capital assets in total investment excluding inventory adjustment as weights.