Asymmetric information, capital structure and agricultural investment

by

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Keywords: Asymmetric information, Agency cost, Agricultural Finance, Investment.

JEL Classification: D29, D82, E22, Q12, Q14.


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Introduction

Capital structure has proved to be a perennial puzzle in finance. If capital market imperfections through informational asymmetries and agency problems are present in the lender - borrower relationship the financial and investment decisions of the farmer are simultaneous and financial decisions affect the growth and investment opportunities potentially imposing a trade-off between production efficiency and financial structure. Supportive, although scant, evidence exists for the presence of capital market imperfection as well as the coherent impact on agricultural investment in the U.S. (Hubbard & Kashyap; Ahrendsen, Collender & Dixon; Bierlen & Featherstone) as well as abroad (Phimister). Recent results by Nasr, Barry and Ellinger provide evidence of a lack of separation between financing and production using agency cost, free cash flow and credit evaluation concept explanations. Barry, Bierlen and Sotomayor concluded also recently that measuring the gap between a firm’s cost of equity and debt arising from capital market imperfections is hampered by absence of relevant data.

Recent developments on informational asymmetries and investment have also, however, focused on the effect of financial constraints and internal cash flow variables without an explicit modeling. A standard approach to analyze the impact of asymmetric information is to either restrict the amount of debt in relation to an imposed constraint or to separate firms into different classes depending on an a priori assumption of the degree of informational asymmetry. A problem with such approaches is that the economic interpretation of statistical tests is blurred since financial constraints are imposed exogenously, and since the endogenous variables, which are used to parameterize the associated multipliers, are not explicitly accounted for when specifying the econometric model (Chirinko; Hansen).
This paper addresses these concerns in two parts. First, the interdependence of finance and investment is explicitly modeled by using Euler equations of a structural model of investment assuming that funds are chosen with the overall objective as to maximize the rationally expected present value of net worth for a homogenous technology. Informational asymmetries and agency problems are modeled as a reduction in output, thus capturing both price- and non-price responses. A convex financial adjustment cost function attributable to asymmetric information and agency problem is introduced. The presence of such a cost function is shown to be sufficient to establish an internal financial optimum without the use of exogenous borrowing constraints since it fills the gap between a firm’s costs of internal and external funds. The first part of the paper thus contributes to the literature by providing a theory for an endogenous determined capital structure in the presence of asymmetric information and its associated relation to agricultural investment.

Endogenous cost functions attributable to information asymmetries has been used previously in the theoretical literature (Kannianen and Södersten) as well as in the empirical literature (Hansen; Benjamin and Phimister) to explain the interdependent investment and financial decision. Kannianen & Södersten modeled costs of monitoring positively dependent on the stock of capital and negatively related to the firm’s indebtedness. Our cost function for agency problems and information asymmetries has the reversed properties. We propose that these costs are mitigated by the existence of capital and non-farm wealth when used as collateral and increased by debt because of costly state verification and adverse selection problems potentially related to higher levels of indebtedness. Benjamin and Phimister invoked implicit and explicit transaction costs that increases linearly with the level of borrowing.

Second, the Euler equations for investment and finance are estimated using the generalized method of moments (GMM) technique (Arellano and Bond) on an unbalanced panel data set from
193 farm operations in Southwestern Minnesota for the 1989-1998 period. This part of the analysis will concentrate on the interdependence of investment and financial adjustment costs to increase the understanding on how fluctuations in investment are attributable to changes in financial decisions. The empirical results support our theoretical model.

**Modeling the investment and financial decision.**

Analyzing the investment and financial decision begins with a value of the farm enterprise. The farm operator is assumed to maximize the net worth $V_s$ of the productive enterprise when evaluating prospective investments over an infinite period. It is also assumed that the operator recognizes that the yield of an investment in any particular asset of the agricultural firm has to be the same as the yields of alternative investments outside the agricultural sector, taking into account discrepancies in tax treatment. For the farm operator to be content in investing in the agricultural firm it must therefore hold for firm $i$ at time $t$ that:

$$\left(1 - \tau^e_{i,t}\right)\rho_{i,t}V_{i,t} = R_{i,t} + E_{i,t}[V_{i,t+1} - V_{i,t}]$$

where $\rho$ is the nominal opportunity rate of return on equity required by the farm operator, $\tau^e$ is the effective marginal tax rate on equity, $R$ is net receipts from the productive enterprise (i.e. withdrawals). Solving (1) forward under the condition that $\lim_{t \to \infty} E_{i,t}[\Pi_{i,t}^\beta_{i,t,a}]V_{i,t} = 0$, i.e. in absence of price bubbles, yields the value of the productive enterprise as:

$$V_{i,t} = E_{i,t}\left[\sum_{t=a}^{\infty} \beta_{i,t,a} R_{i,t}\right]$$

where $\beta_{i,t,a} = \frac{1}{(1 + r_{i,t,a})}$ with $r_{i,t,a} = (1 - \tau^e_{i,t})\rho_{i,t,a}$ denote the one period discount factor. $E_{i,t}$ is the expectation operator. (2) rest on assumptions closely related to the Hubbard and Kashyap study.
Risk aversion is not accounted for since future markets and/or long-terms contracts are available to risk-averse farm operators. In addition, the poor diversification in net worth corresponds to the capital market imperfection, which the model is used to analyze. The farm operator maximizes (2) subject to two constraints.

The first constraint is the standard capital stock identity. Let $\delta$ denote the rate of capacity depreciation at an exponential declining base attributable to the capital stock, then

$$K_{i,s} = I_{i,s} - (1 - \delta) K_{i,s-1}$$  \hspace{1cm} (3)

where $K$ is the capital stock and $I$ is gross investment.

The second constraint to (2) represents the net receipts from the productive enterprise. Net receipts are the residual after taxes, payments to variable inputs, debt service, net change in external funds and investment. Then

$$R_{i,s} = \left(1 - \tau_{i,s}\right) P_{p,i,s} Y_{i,s} - w L_{i,s} - z_{i,s} B_{i,s-1} + B_{i,s} - B_{i,s-1} - \left(1 - \Gamma_{i,s}\right) P_{K,i,s} I_{i,s}$$  \hspace{1cm} (4)

where $Y_{i,s}$ is the output function and $P_{p,i,s}$ is the output price, $w$ and $L$ is vectors of prices and quantities of costlessly adjustable inputs, respectively. $z_{i,s}$ is the nominal cost of external funds. $\Gamma_{i,s}$ is the present value of fiscal allowances per dollar of investment and $P_{K,i,s}$ is the price of capital goods so that the last term in (4) equals the effective cost of investment. $B_{i,s}$ is the amount of outstanding debt (one-period loans) at time $s$. Net receipts are not restricted to be non-negative.

The output function in (4) includes physical output through the technology $F_{i,s}[K_{i,s}, L_{i,s}]$, costs of adjusting the capital stock $G_{i,s}$ as well as costs related to adjusting outstanding debt $A_{i,s}$ so that $Y_{i,s} = F_{i,s} - G_{i,s} - A_{i,s}$. Our approach in modeling the costs of adjusting the capital stock as a reduction in output follows Bond and Meghir; Jaramillo, Sciantarelli and Weiss. The cost of asymmetric information is also modeled as a reduction in the value of output. The argument for our
approach is that both types of adjustments represent extractions of time, effort and resources that could have been better devoted to the farm enterprise. Regarding the cost of asymmetric information, an alternative way should have been to encapsulate such costs in a loan premium paid by the farm above the safe rate, see Jaramillo, Sciantarelli and Weiss (1996). A problem with the latter approach should be that it only captures the price responses to information asymmetries, which historically has been found to be small in the US agriculture (Barry, Baker and Sanit, 1981). More recent results by Miller et al. do however indicate the growing use of risk-adjusted and differential interest rates. Our approach is broader, potentially taking into account non-price responses such as security requirements and effects on output relating to loan maturities, loan supervision, and documentation.

The farm operator then maximizes (2) subject to (3) and (4) using outstanding debt, costlessly variable inputs and gross investment as control variables while the stock of capital is used as a state variable. Applying the discrete time maximum principle on the associated current value Lagrangian and substituting first order conditions for the costlessly adjustable inputs and gross investment into the state equation for capital yields the optimal capital accumulation condition (Euler) as

$$\beta s+1 E_s \left[ (1 - \tau_{s+1}) P_{p,s+1} \left( \frac{\partial F_{s+1}}{\partial K_s} \frac{\partial G_{s+1}}{\partial K_s} + (1 - \delta) \frac{\partial A_{s+1}}{\partial I_{s+1}} \right) + (1 - \delta)(1 - \Gamma_{s+1}) P_{K,s+1} \right] =$$

$$\left( 1 - \tau_s \right) P_{p,s} \frac{\partial G_s}{\partial I_s} + (1 - \Gamma_s) P_K$$

The first order condition (Euler) with respect to outstanding debt is

$$E_s \left[ \beta_{s+1} \left( 1 - \tau_{s+1} \right) \left( P_{p,s+1} \frac{\partial A_{s+1}}{\partial B_s} + z_{s+1} \right) \right] = E_s \left[ \beta_{s+1} \right]$$
The left-hand side of eq. (5) represents the cost of postponing investment until the next-coming period whereas the right hand side represents the costs of investing today. The cost of investing today consists of the marginal adjustment cost and the effective tax-adjusted purchasing cost of investment. The nominal acquisition value is reduced by the present value of fiscal allowances. The cost of waiting includes the foregone change in production, the marginal adjustment cost and the purchasing cost.

Equation (6) describes the conditions for a financial optimum in the farm firm, i.e. equalization of marginal cost across funds available for investment. The right-hand side of (6) describes the expected cost of equity and the left-hand side of (6) captures the expected cost of debt financing. If capital markets are perfect (i.e. absence of cost of financial adjustment) the cost of external funds equals the opportunity cost of equity. However, in presence of capital market imperfections a gap exists between the costs of funds. This gap, as recently noted by Barry, Bierlen and Sotomayor, is consistent with a pecking order of funds. The cost function for financial adjustment fills this gap and reflects lender’s response to informational asymmetries and assures the establishment of an internal financial optimum. Hence, the farm operator should chose funds for investment in period \( s \) so that he equalizes the opportunity rate of return on equity and the marginal cost of external funds. The latter consists of two parts. The first component is the expected after-tax cost of debt in next period. The second component is the incremental cost of adjusting outstanding debt. It should be noted that even in case of a cost-disadvantage for equity over debt the financial equilibrium will exist for sufficiently large investments since the cost function for financial adjustment is strictly increasing in the level of debt (see below).
Empirical specification

The adjustment cost function in (5) represents additional costs to the farm enterprise when increasing (or decreasing) the capital stock. Adjustment costs based on the work by Eisner and Strotz; Lucas, imposing that changes in the quasi-fixed factor demands are smooth and symmetric, have shown to be substantial in farm size expansion (Vasavda & Chambers; Weersink & Tauer; Lopez; Thijssen). Recent research by Chang and Stefanou; Oude Lansink and Stefanou have developed a threshold model of adjustment costs, and provided empirical support for that adjustment may be faster when investment is contracting rather than expanding.

Here, the basic specification of the adjustment cost follows Bond and Meghir; Withed and the adjustment cost function is assumed to be strictly convex and exogenously given by observable variables, the latter property is not fulfilled within threshold approaches. Hence

\[
G_{i,t}(I_{i,t}, K_{i,t-1}) = \frac{\alpha}{2} \left( \frac{I_{i,t} - \delta}{K_{i,t-1}} \right)^2 K_{i,t-1}
\]

(7)

where \(\alpha\) is the adjustment cost constant parameter giving the magnitude. The location of symmetry equals the rate of capacity depreciation \(\delta\), stating that no adjustment cost prevails in steady state\(^1\). It should be noted that (7) implies economies of scale in adjusting investment. The larger the farm is (measured by the capital stock), the less any given investment will displace resources (reduce output).

The cost function attributable to information asymmetries \(A(\cdot)\) captures the economic implications of adjusting the stock of external funds. The cost of information asymmetries is modeled as a continuous and differentiable convex function which increases in the amount of debt...
and decreases in the amount of capital and non-farm wealth so that $A_B > 0$, $A_K A_W < 0$ and the second-order conditions $A_{BB} A_{KK} A_{WW} > 0$, $A_{BK} A_{BW} < 0$ (competitiveness) and $A_{KW} > 0$ (complements). A parameterization that adheres to this specification is

$$A_{i,s}(B_{i,s-1}, K_{i,s-1}, W_{i,s-1}) = \frac{\phi}{2} \left( \frac{B_{i,s-1}}{K_{i,s-1} + W_{i,s-1}} - \nu \right)^2 \left( K_{i,s-1} + W_{i,s-1} \right)$$

(8)

where $\phi$ and $\nu$ represents the constant magnitude parameter and the location of minimum costs of information asymmetries, respectively.

The agency cost problems of adjusting the stock of external funds as captured by (8) relates both to the ex ante evaluation of investment and the farm operator as well as to the ex post monitoring of performance. The functional form of (8) implies a U-shaped agency cost curve defined as the sum of the positive (cost increasing) augmentation in external funds and the negative (cost decreasing) augmentation in the stocks of capital and non-farm wealth. In cases where farm assets for use as collateral is limited in supply or not sufficient, non-farm wealth may be used as a substitute since there is no clear-cut between business assets and private assets more than that attributed to the actual use in the proprietorship.

The upward sloping part of the agency cost curve defined by (8) is from the ex ante perspective motivated adverse selection and moral hazard. The farm operator has private information about the chances of success of each investment project and the lender has to sort out viable investments and borrowers that will fulfill their contractual debt service but it is costly finding out. From the ex post perspective monitoring of performance or contractual control of outcomes and managerial actions represents costly state verification problems. If the ex post

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1 If costs of adjusting the capital stock were supposed to be absent when no investment is undertaken, an alternative specification would have been (time and firm indexes suppressed) $G(\cdot) = \alpha \left( I/K - 2\nu \right)$. A problem with this
monitoring is costly, or in the worst case impossible, the lender may not know the right time to take control of or to default a badly managed firm. Delays of this type may constitute considerable costs to both the lender and the borrower.

The downward sloping part of the agency cost curve defined by (8) is motivated by the role of collateral as a way of hampering problems of adverse selection and moral hazard. It is well known from the Siglitz-Weiss model that the low-risk borrower by accepting collateral requirement credibly signal his status and thereby reduces the problems of adverse selection. Problems of moral hazard can also, following Bester, be reduced by the use of collateral as a bonding device. Bester points out that business owners may resist the provision of personal guarantee since such requirements if raised erodes limited liability status. This arguments is, however, not applicable for proprietary firms due to lack of limited liability and since there is no clear cut between business assets and private assets more that that attributable to the actual use in the proprietorship. The economic consequences of the non-limited liability status are at least twofold. First, since in fact non-farm collateral is implicitly used when a farmer offers collateral for a loan, the incentive to exert effort ought to be reinforced and problems of moral hazard ought to be reduced. Secondly, and at the other hand, when the farmer recognizes that personal collateral is asked for and used to secure loan applications his personal risk increases. One way to off-balance the risk, while still using debt is to invest in safer projects than else would have been motivated. In times of a changing productive environment, this off-balancing strategy could be hazardous to both the farmer and the lender in the long run and affecting the output negatively. In addition, the value or volume of either farm assets and non farm assets may be insufficient, particularly in instances where the lender rely on some forced liquidation value of the assets and not on their value in best use. Thus the asset illiquidity functional form is however that there exists two roots, $2v$ and $0$. 
value is of relevance in using collateral to secure loans. Conclusively, the downward sloping part balances the incentive (and cost reducing) effects of collateral against the discouraging effects.

**Data and summary statistics**

The data used to estimate the investment and financial Euler 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 farm operations, only sole proprietors are included. 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. That left the final panel to be constructed out of observations from 193 farm operations with a total of 1308 observations. The panel is unbalanced both in the sense that there is more observations on some farm than on others and because these observations corresponds to different points in time. 52 percent of the farm operations were represented in the panel for at least 7 years and the panel ranges over the 1990-1998 period.

Prices on 17 major commodities for Minnesota were collected from the National Agricultural Statistics Service (NASS) in order to obtain an aggregated individual price index for each farm operation in the panel representing the individual price of output. It was not possible to construct a Tornqvist index due to missing information on quantities for some products. Instead a price index was constructed for each commodity. The individual total firm price index was then constructed by weighting the price index for each good. The share of sales of the each good in total sales represented the weights.

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 farm lands 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.

The Data Appendix provides a further detailed description of the variables used in the empirical analysis. Summary statistics for the variables and other farm characteristics are reported in Table 1.

Table 1 Summary statistics for selected variables for 193 sole proprietorships in Southwestern Minnesota 1990-1998.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( I_{s+1}/K_{s,t} )</td>
<td>0.114</td>
<td>0.063</td>
<td>0.266</td>
</tr>
<tr>
<td>( B_{s}/(K_{s}+W_{s}) )</td>
<td>0.411</td>
<td>0.383</td>
<td>0.285</td>
</tr>
<tr>
<td>( B_{s}/K_{s} )</td>
<td>0.432</td>
<td>0.397</td>
<td>0.325</td>
</tr>
<tr>
<td>( cf_{s+1}/K_{s} )</td>
<td>0.137</td>
<td>0.125</td>
<td>0.301</td>
</tr>
<tr>
<td>ECP (index)</td>
<td>1.282</td>
<td>1.233</td>
<td>0.372</td>
</tr>
<tr>
<td>EPP (index)</td>
<td>1.041</td>
<td>0.985</td>
<td>0.339</td>
</tr>
<tr>
<td>((1-\tau_{s,s+1})z_{s,s+1} )</td>
<td>0.048</td>
<td>0.046</td>
<td>0.026</td>
</tr>
<tr>
<td>( r_{i,t} )</td>
<td>0.056</td>
<td>0.054</td>
<td>0.009</td>
</tr>
<tr>
<td>( K_{s} ) ($)</td>
<td>687.449</td>
<td>557.961</td>
<td>483.826</td>
</tr>
<tr>
<td>( W_{s} ) ($)</td>
<td>36.485</td>
<td>7.483</td>
<td>71.980</td>
</tr>
<tr>
<td>( B_{s} ) ($)</td>
<td>266.040</td>
<td>214.677</td>
<td>238.569</td>
</tr>
</tbody>
</table>

Notes:
\[ cf_{s+1}/K_{s} = (Y_{s+1} - (w_{s+1}/P_{p,s+1})L_{s+1})/K_{s} \] is (operating income minus operating expenses)/beginning value of capital stock. Used as a proxy for cash flow.
\[ ECP = (1-\Gamma_{s+1})P_{K,s+1}/(1-\tau_{s})P_{p,s} \] is effective price of capital/effective price received on products sold.
\[ EPP = (1-\tau_{s,s+1})P_{p,s+1}/(1-\tau_{s})P_{p,s} \] is effective price received on products sold in period \( s+1 \)/effective price received on products sold in period \( s \).

Table 2 reveals farm characteristics to allow the comparison of results across classes of firms and between groups of farm operators. Firms with these types of characteristics have been found in the financial constraint literature and in the recent literature on asymmetric costs of adjusting the capital
stock to have different patterns of investment and financing behavior. These characteristics are the subsequently used to formulate dummy variables.

Annual sales are used as a proxy for farm size and annual sales less than $150,000 is set to classify a small farm. Two competing characteristics, age of senior operator and years in farming for the senior operator, are used to capture differences in managerial styles and abilities. The investment dummy is invoked to test if costs of adjustment differ depending on if farm operations are in an investment regime or in a no investment regime. The dummy on new borrowing is invoked for similar reasons. In addition, three combined dummies are invoked. The first characterizes firms that are both investing and borrowing. The second represents small farms with a young operator and the third combined dummy variable is formed to characterize a currently investing small farm with a junior operator. The farm operations were also classified into three groups to identify a highly specialized production. The farms were identified as crop-, beef and dairy- or hog production by the requirement of having more than 60 percent of total sales in these categories. This sorting resulted in 500 observations attributable to crop production, 140 observations for beef and dairy production, and 177 observations for hog production.
<table>
<thead>
<tr>
<th>Characteristics</th>
<th>share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual sales &lt; $150 000</td>
<td>0.22</td>
</tr>
<tr>
<td>Senior operator age &lt;40 years</td>
<td>0.29</td>
</tr>
<tr>
<td>Years in farming for the senior operator&lt;10 years</td>
<td>0.078</td>
</tr>
<tr>
<td>Investment&gt;0</td>
<td>0.79</td>
</tr>
<tr>
<td>New borrowing</td>
<td>0.59</td>
</tr>
<tr>
<td>Investment and new borrowing</td>
<td>0.52</td>
</tr>
<tr>
<td>Annual sales &lt;$150 000 and years in farming for senior operator&lt;10 years</td>
<td>0.03</td>
</tr>
<tr>
<td>Investment&gt;0, annual sales &lt;$150 000 and years in farming for senior operator&lt;10 years</td>
<td>0.023</td>
</tr>
<tr>
<td>Cash flow to capital (cf/K) &lt; 7%</td>
<td>0.20</td>
</tr>
<tr>
<td>Non-farm wealth = 0</td>
<td>0.41</td>
</tr>
</tbody>
</table>

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.

**Econometric Specification and Results**

The dynamic Euler equations for investment and financing 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 investment equation and also since appropriately lagged instruments for endogenous explanatory variables are required. 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 ortogonality 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 overidentifying restrictions hold. The Sargan test is chi-square distributed with as
many degrees of freedom as overidentifying 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.

The investment equation
An estimable capital accumulation relationship is obtained in three steps. First, with the benefit of
not having to specify a parametric form of the production function the net marginal output in the
left-hand side of (5) is substituted according to the Euler Theorem\(^2\). This approach follows Bond
and Meghir; Jaramillo, Schiantarelli and Weiss. Secondly, the partial derivative of the production
function with respect to the costlessly adjustable input is replaced by the first-order condition
\[ \frac{\partial F}{\partial L} = w / p_p. \]
The final step is to incorporate the partial derivatives of the adjustment cost function
as well as the cost function attributable to information asymmetries. Using the rational expectations
assumption expected values are replaced by actual values and a serially uncorrelated forecast error
\[ e_{t+1}, \]
so that the Euler equation for capital becomes (firm index suppressed):

\[ \frac{\partial F}{\partial K} - \frac{\partial G}{\partial K} - \frac{\partial A}{\partial K} = \frac{Y}{K} - \frac{\partial F}{\partial L} \frac{L}{K} + \frac{\partial G}{\partial I} \frac{I}{K} + \frac{\partial A}{\partial B} \frac{B}{K} + \frac{\partial A}{\partial W} \frac{W}{K}. \]

\(^2\) The Euler Theorem implies that:
\[
\begin{align*}
\beta_{s+1} \left\{ \frac{(1-\tau_{s+1})P_{p,s+1}}{(1-\tau_{s})P_{p,s}} \right\} & \frac{Y_{s+1} - \left( \frac{W_{s+1}}{P_{p,s+1}} \right) L_{s+1}}{K_s} + \alpha \left( \frac{I_{s+1} - \delta}{K_s} \right) K + \phi \left( \frac{B_s}{(K_s+W_s)} - \nu \right)
\end{align*}
\]

\[
\frac{(1-\delta)(1-\delta)P_{K,s+1}}{(1-\tau_{s})P_{p,s}}
\]

\[
\frac{(1-\delta)(1-\delta)P_{K,s+1}}{(1-\tau_{s})P_{p,s}}
\]

\[
\frac{(1-\delta)(1-\delta)P_{K,s+1}}{(1-\tau_{s})P_{p,s}}
\]

\[
\frac{(1-\delta)(1-\delta)P_{K,s+1}}{(1-\tau_{s})P_{p,s}}
\]

\[
\frac{(1-\delta)(1-\delta)P_{K,s+1}}{(1-\tau_{s})P_{p,s}}
\]

where \( f \) and \( t \) represents fixed effects and time effects, respectively.

Table 3 show the results for estimating various versions of the Euler equation (9). Three structural parameters are recovered: \( \alpha \), the quadratic adjustment cost parameter; \( \phi \), the quadratic parameter capturing the level of the agency cost function, and \( \nu \), the debt to capital and non-farm wealth ratio that provides the location of minimum costs attributable to agency problems and information asymmetries. The set of instruments includes the regressors as well as dummy variables lagged two periods.

The analysis presented is sequential. In column (a) time effects are included when estimating (9). The inclusion of time effects improves the fit of the model and the Wald statistics support the inclusion of time dummies. Time dummies for 1994, 1997 and 1998 were significant at the five percent level (1994) and at the one percent level (1997, 1998) with negative signs indicating that the farms represented in the sample exhibited a lower investment to capital ration during these years. Time effects were therefore allowed for in the subsequent versions. In column (b) a dummy was included to identify farms with positive levels of investment. In column (c) an interactive dummy is included to identify farm that both invest and increase borrowing. In column (d) an interactive dummy variable is included to identify small farm operations with a younger farm operator. Finally,
in column (e) a dummy variable is included to identify small farms with a young farm operator that has a positive level of investment.

### Table 3. Estimates of investment equation (9), (sample period 1990-1998)

<table>
<thead>
<tr>
<th></th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
<th>(e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>α</td>
<td>0.884***</td>
<td>0.857***</td>
<td>0.892***</td>
<td>0.948***</td>
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<tr>
<td>φ</td>
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<td>1.30*</td>
<td>1.438*</td>
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<td>(0.85)</td>
<td>(0.85)</td>
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<td>ν</td>
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<td>0.66</td>
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<tr>
<td>(St. dev)</td>
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<td>(0.00)</td>
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<td>Sargan</td>
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<td>135.1</td>
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<td>p-value</td>
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<td>(0.252)</td>
<td>(0.412)</td>
<td>(0.368)</td>
<td>(0.296)</td>
</tr>
</tbody>
</table>

*** Indicates statistical significance at the one percent level
** Indicates statistical significance at the five percent level
* Indicates statistical significance at the ten percent level

Notes: (St. dev) - standard deviation. W(1) - 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.

For all cases represented in Table 3 the estimated values of the adjustment cost parameter α is highly significant and low but fairly reasonable. Hubbard and Kashyap reports a value of a about 1.05 on equipment investment in the U. S. agricultural sector. Withed reports a value of 2.026 for large industrial firms. The economic significance of this parameter can be seen from eq. (7). Since the rate of economic depreciation (equal to the ratio of investment to capital that minimizes the cost of adjustment) is assumed to be 6 percent a value of α−value equal to 0.884 implies that adjustment costs will be 2.4% of investment expenditures for a farm that invests $102 000 on a capital stock of $ 680 000.
The value of $\alpha$ in column (b) are slightly discouraging and indicates that farms in an expanding regime have lower costs of adjustment compared to farms that have zero or negative investment ratios. Oude Lansink and Sefanou found that the adjustment rate is higher in the contracting regime than in the expanding regime for a set of specialized Dutch cash crop farms. Although, by including the interacting effect of new borrowing and positive levels of investment column (c) then reveals a higher $\alpha$ compared to column (b). This could indicate that a higher adjustment cost in expansion is triggered by the acquisition of funds for investment. Also, the $\alpha$-values in columns (e) and (f) suggests that the costs of adjustment is higher for small farms with a young operator and highest for small farms with a young operator that are in an expanding regime. It should however be noted that the estimated $\alpha$-values remain in the same 95 percent confidence interval so that the interpretation of differences between them may only be tentative.

The results in Table 3 also suggests that agency problems and information asymmetries lowers the level of output. The level of the agency cost function is significant at the 10 percent level and the estimated values for the level parameter exceeds the $\alpha$-parameter. This is a notable result indicating that output is more hampered by capital market imperfections than by costs of installing new capital. According to (7) a value of $\phi$ equal to 1.33 means gives for a farm that chooses a debt to capital and non-farm ratio deviating 10 percentage units from the location of the minimal agency cost incurs a loss/gain of $4522 if the stock of capital and non-farm wealth amounts to $680 000. The implied estimate for $\phi$ is higher for farms that rises debt and invests, have low incomes and a younger farm operator, and is highest for expanding farms with low incomes and a younger operator.

The debt to capital and non-farm wealth location of minimum costs differs across the cases revealed in Table 3, as one would expect, although the effect is not significant. A cautious
interpretation ($t$-value = 0.744) suggest that farms in an expansion regime of investment and borrowing should choose higher debt levels as compared to other farms in order to lower the costs of capital market imperfections. One explanation to this could be a larger availability of assets suitable as collateral. Columns (d) and (e) also suggest that small farm with a less experienced operator should have a lower debt to capital and non-farm wealth ratio as compared to other farms. The $t$-values in column (d) and (e) are 0.465 and 0.549, respectively. Along another line of research Bierlen and Featherstone reports that the debt level was the strongest determinant of credit constraint for younger farm operators (age<41 years). Our results is therefore reasonable.

The Euler equation (9) was also estimated by including dummy variables to identify highly specialized production units. The estimation for crop farms (not shown) yielded highly insignificant $\alpha$ and $\phi$-values, although the $\nu$ parameter was significant at the 10 percent level. The Wald (joint) and Sargan statistics supported the specification. The $p$-values for those statistics were 0.00 and 0.479, respectively. This suggests that adjustment costs are less important for specialized crop farm as compared to other types of farms. We were not able to do similar estimations for farm specialized in beef and dairy, and hog production due to singular instrumental matrices.

Finally, tests was done to check whether a low cash flow to capital ratio ($cf/K<0.07$), absence of non-farm wealth ($W = 0$) or a low operator age (age<40 years) could be significant in estimating eq. (9). The tests confirmed that neither of these characteristics were significant. Although, among them a low cash flow was the one most significant ($p$-value = 0.243).

The financial equation

An estimable financial Euler equation is obtained from (6) by substituting the partial derivatives of (8) with respect to borrowing and by replacing expected values with actual values and a forecast error so that (firm index suppressed):
\[ r_{s+1} - (1 - \tau_{s+1}) \left[ P_{p,s+1} \phi \left( \frac{B_x}{K_s + W_s} - \nu \right) + z_{i,s+1} \right] + f + t = e_{s+1} \]  

(10)

where \( f \) and \( t \) represents fixed effects and time effects, respectively.

Table 4 shows the result for estimating various versions of the Euler equation (10). The effective after tax interest rate was used as the dependent variable and two structural parameters \( \phi \) and \( \nu \) is recovered. The set of instruments included the regressors as well as \( B/(K+W) \), \( I/K \) and \( cf/K \) and additional dummies. Each instrument is lagged two and three periods. The one-step estimation of equation (10) provided only weak support for the model. The Sargan statistic was 62.54 for 53 degrees of freedom. The estimation was therefore done by the two-step heteroskedasticity consistent procedure.

Column (a) reveals the results obtained when estimating (10) without time effects. Time effects were rejected by the Wald statistics in a separate estimation (not shown) and are therefore left out of consideration in the following. In column (b) a dummy is included to identify farms that raises new debt and invests. In column (c) a dummy is included to identify farm operators younger than 40 years and in column (d) a dummy is included to identify farm operators with less than 10 years of experience in farming. Column (e) then represents small farms with less experienced farm operators. Column (f) finally reveals the results for small farms with less experienced farm operators that raises new debt and invests.
### Table 4. Estimates of financial equation (10), (sample period 1990-1998)

<table>
<thead>
<tr>
<th></th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
<th>(e)</th>
<th>(f)</th>
</tr>
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<tbody>
<tr>
<td>φ</td>
<td>0.024***</td>
<td>0.017***</td>
<td>0.019***</td>
<td>0.02***</td>
<td>0.033***</td>
<td>0.027***</td>
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<tr>
<td></td>
<td>(0.005)</td>
<td>(0.002)</td>
<td>(0.002)</td>
<td>(0.005)</td>
<td>(0.006)</td>
<td>(0.005)</td>
</tr>
<tr>
<td>ν</td>
<td>0.518***</td>
<td>1.26***</td>
<td>0.867***</td>
<td>0.62***</td>
<td>0.214</td>
<td>0.419***</td>
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<tr>
<td></td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.005)</td>
<td>(0.004)</td>
<td>(0.006)</td>
<td></td>
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<tr>
<td>W(joint)</td>
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<td>134.7</td>
<td>147.4</td>
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<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
</tr>
<tr>
<td>Sargan</td>
<td>52.95</td>
<td>60.27</td>
<td>51.89</td>
<td>52.41</td>
<td>57.33</td>
<td>56.78</td>
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<td>p-value</td>
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<td>(0.536)</td>
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<td>AR(1)</td>
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<td>-4.06</td>
<td>-4.21</td>
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<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
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<tr>
<td>AR(2)</td>
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<td>-0.52</td>
<td>-0.32</td>
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<tr>
<td>p-value</td>
<td>(0.68)</td>
<td>(0.49)</td>
<td>(0.61)</td>
<td>(0.75)</td>
<td>(0.76)</td>
<td>(0.715)</td>
</tr>
</tbody>
</table>

*** Indicates statistical significance at the one percent level

Notes: W(1) - 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.

The results shown in Table 4 strongly support the hypothesis that agency problems and information asymmetries affect the capital structure. A value of $\phi$ around 0.024 implies that adjustment costs due to agency problems and information asymmetries is less affective to financial decisions as compared to capital accumulation decisions. The agency cost level parameter is higher for small farms with less experienced farm operators (column (e)), and also for the sample of small farms with less experienced farmers that are expanding their business (column (f)).

In relation to Table 3 we now find that the estimates of the $\nu$-parameter, the debt to capital and non-farm equity that minimizes the agency costs, is significant at the one percent level except in column (e) were a $p$-value of 0.244 is obtained. The suggested levels of the minimum location reported in columns (e) and (f) again implies that it is optimal for farms/farmers that a priori is expected to face problems of costs and availability of credit to have a lower level of indebtedness.

Although columns (c) and (d) in Table 4 reflects the same thing in form of farmer characteristic, young operator or less experienced operator, the estimated location of minimum agency costs differs. A comparison stresses that less experience in farming is more suggestive for a
lower indebtedness than the age of the operator. Again, in lack of other studies we can not generalize this finding.

The Euler equation (10) was also estimated by including dummy variables to identify highly specialized production units. The estimation for crop farms (not shown) yielded significant $\phi$- and $\nu$-parameter values but the $\nu$-value is unreasonably large (around 2.57). The Wald (dummy) test was significant at the one percent level but the AR(1) test rejected the existence of first-order serial correlation. We were not able to do similar estimations for farm specialized in beef and dairy, and hog production due to singular instrumental matrixes.

Finally, neither a low cash flow to capital ratio ($cf/K<0.07$) nor absence of non-farm wealth ($W = 0$) were significant in eq. (10). Although, a low cash flow was the one most significant factor ($p$-value = 0.50). The result that farms with low cash flows does not seems to differ in respect to agency costs in relation to farms with higher cash flow is surprising in light of the positive effect of cash flows in resolving asymmetric information reported by Jensen, Lawson and Langemeier.

**Concluding comments**

This paper has provided a new theory for an endogenous capital structure for the proprietor farm in the presence of asymmetric information and agency problems in the lender-borrower relationship by introducing a financial agency cost function. In the financial optimum internal and external funds (i.e. debt) are chosen so that the cost of internal funds equals the after-tax cost of debt and the marginal agency cost. The optimal leverage is not at the minimum level of agency cost but rather were the positive and negative effects of informational symmetries fills the gap between costs of equity and debt.
The empirical results supports the theory and reveals supportive evidence for that costs of asymmetric information and agency problem affects the capital accumulation decisions as well as capital structure decisions.

References


## Data Appendix

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{i,s}$</td>
<td>Real 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.</td>
</tr>
<tr>
<td>$P_{p,s}Y_{s}$</td>
<td>Value of total sales. Equals cash farm income minus patronage dividends, insurance income, and cash from hedging.</td>
</tr>
<tr>
<td>$w_{s}L_{s}$</td>
<td>Variable costs. Equals cash farm expenses minus interest, personal property taxes, and hedging account deposits.</td>
</tr>
<tr>
<td>$B_{s}$</td>
<td>Book value of total loan liabilities.</td>
</tr>
<tr>
<td>$z_{s}$</td>
<td>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.</td>
</tr>
<tr>
<td>$W_{s}$</td>
<td>Personal wealth. Includes non-farm savings, stocks and bonds and real estate.</td>
</tr>
<tr>
<td>$K_{s}$</td>
<td>Value of capital stock at fair market value. Includes breeding livestock, machinery and farm equipment, other interim assets, farm buildings, farmland, and other long-term farm assets. Includes growing crops, crops and feed and market livestock.</td>
</tr>
<tr>
<td>$\tau_{s}$</td>
<td>Marginal tax rates on farm income. Includes federal income tax, self-employment tax and state income tax. Calculated for each firm and year.</td>
</tr>
<tr>
<td>$\tau^{e}$</td>
<td>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.</td>
</tr>
<tr>
<td>$\Gamma_{s}$</td>
<td>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.</td>
</tr>
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<td>$D_{1}$</td>
<td>Dummy variable. If crop farm, then $D_{1}=1$, else 0.</td>
</tr>
<tr>
<td>$D_{2}$</td>
<td>Dummy variable. If small farm, then $D_{2}=1$, else 0.</td>
</tr>
<tr>
<td>$D_{3}$</td>
<td>Dummy variable. If new long-term debt, then $D_{3}=1$, else 0.</td>
</tr>
<tr>
<td>$D_{4}$</td>
<td>Dummy variable. If senior operator age&lt;40, then $D_{4}=1$, else 0.</td>
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<tr>
<td>$D_{5}$</td>
<td>Dummy variable. If years in farming&lt;10, then $D_{5}=1$, else 0.</td>
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