Farm Capital Structure Choice under Credit Constraint: Theory and Application

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Abstract

This study proposed a theoretical framework for analyzing farm capital structure choice. The theoretical model recognizes that the costs of debt are endogenously determined which in turn reflect the degree of credit constraint faced by individual borrowers. Based on the proposed model, we derived the impacts of different determinants on capital structure choice analytically. The theoretical inferences are further tested with empirical data. Methodologically, we proposed a fixed-effect quantile regression procedure to estimate the impacts of determinants at different ranges of leverage. The effects of determinants are discussed in the empirical application.

Key words: Capital Structure, Cost of Debt, Credit Constraint, Quantile Regression,

In the finance literature different theories have been proposed to explain firm capital structure choice. The theories include the tradeoff theory (Miller, 1977), pecking order theory (Myers, 1984), agency theory (Jensen and Meckling, 1976), and market timing theory (Baker and Wurgler, 2002). Given the corporate focus of this literature, few of these theories can be directly applied to the farm business setting, as farm businesses are fundamentally different from corporate firms in many aspects and farmers may have different patterns of decision making (Guan and Oude Lansink, 2006). In the agricultural economics literature Collins (1985) and Barry, Baker, and Sanint (1981) proposed an expected utility model (hereafter referred as Collins-Barry model) for analyzing optimal capital structure choice. In the Collins-Barry model the capital structure (debt ratio) is a decision variable and the optimal debt ratio is found when the farmers' expected utility is maximized. The impact of different factors on the choice of capital structure can then be analyzed and tested. The utility maximization model provides a useful tool for empirical capital structure analysis and is widely accepted in the literature. However, the empirical evidence is not always in agreement with this model (Ahrendsen, Collender and Dixon, 1994).

The Collins-Barry model is an unconstrained utility maximization model. Without accounting for credit constraint, the model implicitly assumes that farmers have full access to credit. However, credit constraint is common in farm businesses due to the absence of equity market, a substantial lag between the purchase of inputs and the sale of outputs, and undiversified and inflexibly held capital (Bierlen et al., 1998). There are some theoretical studies investigating capital structure choice under credit constraint. Robison and lev (1986) examined the effects of various forms of credit constraint on borrowing behavior and found that they can explain the "go for broke" phenomenon that arises from a willingness to incur greater financial risk as the proprietary firm's survival is threatened. Robison, Barry, and Burghardt (1987) extend the previous work to examine the effects of financial stress and limitation of liability on borrowing behavior. Compared to the Collins-Barry's unconstrained model, these studies focus on the extreme case of financial stress where farms are constrained by strict credit limit. Instead of the two extreme, special cases, it is more common that farms are faced with differing degrees of credit constraint, which calls for a generalized capital structure model.

In the existing literature there are only some ad hoc studies investigating the effect of credit constraint on farmers' capital structure decision (Barry et al., 2000; Bierlen et al., 1998). In these studies, a common issue is how to proxy credit constraint. The existing studies simply groups data using criteria of age and the credit score (Barry et al., 2000), or business cycle (Bierlen et al., 1998) to reflect the degree of credit constraint in different groups and examine the effect of one or several farm attributes on capital structure decision. The grouping approach in the literature may not correctly capture credit constraint and therefore result in incorrect conclusions. In addition, grouping data is likely to create a sample selection problem in terms of econometrics.

The limitations in theory and methodology clearly point to the need of further research. The objective of this study is twofold, both theoretical and methodological. Theoretically, we propose a generalized farm capital structure choice model applicable to differing degrees of credit constraint. We develop an optimization model that takes account of credit constraint. The model provides a general conceptual framework for analyzing factors that affect farm capital structure decisions. We use the cost of borrowing as a constraint in the utility maximization model. We argue that the differing cost of borrowing among borrowers is endogenous and provides an ideal proxy for the degrees of credit constraint in the light of credit risk evaluation conducted by lenders when approving loans and determining the interest rate. Based on this generalized model, impacts of different determinants of farm capital structure are derived analytically and further tested empirically. Methodologically, we propose to use quantile regression to test the theoretical results. Quantile regression can evaluate the varying effects of explanatory variables on dependent variables when the dependent variable takes on values in different ranges. Use of the quantitle method avoids spurious regression and sample selection problem[1]. We further employ Chamberlain (1982) and Mundlak (1978) approach to addressing the potential heterogeneity and allowing for

[1] Koenker and Basset (1978) indicate that it is the faulty notion that something like quantile regression could be achieved by segmenting the response variable into subsets according to its unconditional distribution and then doing least squares fitting on these subsets.

correlation between explanatory variables and the farm-specified effect, which constitutes an additional methodological contributions of this work.

Collins-Barry Model

The Collins-Barry model assumes that farmers maximize the expected utility of the rate of return on equity capital[2] when making capital structure choice. If incorporating the tax shield from depreciation, the extended Collins-Barry model would take the following form:

(1)
$$\hat{\gamma}_E = \frac{(r_0\hat{\tau}A - u_D D)(1-\varphi) + pA\varphi}{E}$$
$$= [(r_0\hat{\tau}(1+\delta) - u_D\delta)](1-\varphi) + p\varphi(1+\delta)]$$

where $\hat{\gamma}_E$ is the stochastic rate of return to equity. A is total asset. E is total equity. D is total debt. The leverage ratio $\delta = D/E$. r_0 is the ratio of the previous-period earnings before interest, tax, and depreciation (EBITD) to total assets. $\hat{\tau}$ denotes growth index of return, which is defined as one plus growth rate. The index is the stochastic, with mean u_τ and variance σ_τ^2, u_D is the interest rate charged by lenders, assumed to be exogenous. p is the assets depreciation rate, and ψ is exogenously determined ordinary tax rate.

The expected rate of return on equity is

(2)
$$E(\hat{\gamma}_E) = [(r_0 u_\tau(1+\delta) - u_D\delta)](1-\varphi) + p\varphi(1+\delta)]$$

The Variance of $\hat{\gamma}_E$ is

(3)
$$\mathrm{Var}(\hat{\gamma}_E) = r_0^2(1+\delta)^2(1-\varphi)^2\sigma_\tau^2$$

The variance of the rate of return on equity is the total risk farmers have to face, which can be decomposed into business risk $r_0^2(1-\varphi)^2\sigma_\tau^2$ and finance risk $(1+\delta)^2$.

[2] Collins (1985) considers that a focus on return to assets is not appropriate for a proprietorship, because there is no reason to expect capital structure to affect the rate of the return on assets (before interest) except in the extreme case. Meanwhile, he excludes maximizing the market value of the debt and equity in respect that efficient markets for the equity do not exist.

Assuming a negative exponential utility function and a normal distribution of the stochastic variable, Freund (1956) demonstrated that the expected utility-maximizing solution may be obtained by maximizing the certainty equivalent of return on equity with respect to leverage ratio:

$$\text{(4)} \quad \max_{\delta}\{E[U(\hat{\gamma}_E)]\} = \max_{\delta}[CE(\hat{\gamma}_E)] = \max_{\delta}[E(\hat{\gamma}_E) - \frac{1}{2}\rho Var(\hat{\gamma}_E)]$$
$$= \max_{\delta}\left\{[(r_0 u_\tau(1+\delta) - u_D\delta)](1-\varphi) + p\varphi(1+\delta) - \frac{1}{2}\rho r_0^2(1+\delta)^2(1-\varphi)^2\sigma_\tau^2\right\}$$

where $U(\cdot)$ is utility function and ρ is the Arrow-Pratt measure of farmer's absolute risk aversion.

By rearranging the first-order necessary condition for maximizing the expected utility, optimal leverage ratio is

$$\text{(5)} \quad \delta^* = \frac{(r_0 u_\tau - u_D)(1-\varphi) + p\varphi}{\rho r_0^2(1-\varphi)^2\sigma_\tau^2} - 1$$

The second-order condition holds if the proprietor is risk averse.

Comparative static analysis shows that risk-averse level (ρ), volatility (σ_τ^2), and interest rate (u_D) are negatively related to optimal leverage ratio, while expected growth index (u_τ) and depreciation rate (*p*) is positively related to leverage. The previous-period rate of return on assets (r_0) has an ambiguous relationship with leverage. The comparative static results imply that farms with high depreciation rate may issue more debt, which is inconsistent with the argument in the corporate finance literature. In the corporate firm setting, the tax shield of debt can be substituted with non-debt corporate tax shield, such as depreciation deductions. Ahrendsen, Collender and Dixon (1994) attribute the positive effect to the major difference between corporate firms and farms: access to equity markets. Because of the lack of access to equity markets, farmers often select scale and capital structure simultaneously: farm with more fixed assets should also have more debt.

The Generalized Model

Cost of debt and credit constraint

Collins (1985) assumes that the cost of debt (i.e. interest rate) is exogenous, constant, and independent of leverage ratio. The assumption is reasonable in the macroeconomic context as the equilibrium interest rate is determined by market supply and demand. However, in the microeconomic environment, the interest rate charged by lenders is time-variant, stochastic, and endogenously determined by farm/operator characteristics. In the agricultural credit market, lenders generally set the interest rate according to the degree of the borrower's creditworthiness. Lenders usually use professional tools, such as the default probability model (or credit evaluation model), to evaluate the risks associated with loan applications. The default probability model[3] is used in loan approval decision and to price loans. Farmers with a higher default probability will be charged a higher interest rate. Hence, the rate offered by lenders embodies information on the credit risk and the degree of credit constraint of farmers.

When the credit risk reaches a certain threshold, the bank would reject the offer even if borrowers would offer to pay a high interest rate. This means un-clearing market, which is inconsistent with the classical price theory. Stiglitz and Weiss (1981) attribute it to negative adverse selection and incentive effects: an increase in the rate of interest causes adverse selection, since only borrowers with riskier investments will apply for a loan at a higher interest rate. Similarly, higher interest payments create an incentive for investors to choose projects with a higher probability of bankruptcy. Thus some borrowers would not receive a loan even if they offer a high interest. This can be illustrated in figure 1.

Figure 1 shows interest rate faced by farmers. i_0 is the minimum interest rate at which most banks charge their best customers, who in general have little credit risk. With an increase in the default probability, the lender would charge a higher interest rate for the additional risk till the

[3] In the past decades, greater precision in credit evaluation of agricultural borrowers has occurred.

default probability reaches the threshold ω (i.e., the maximum risk the lender would bear) [4], at which point the lender stops supplying loans, however high the interest rate is offered. At the threshold, a complete constraint occurs, and farmers are blocked out of the credit market. This is equivalent to having an infinite interest rate

We propose to use the endogenously determined cost of debt as a generalized form of credit constraints. We will further incorporate this into a utility maximization model as a constraint. The general cost of debt model and PD relationship is developed as:

$$u_D = \frac{\emptyset}{\omega - PD} + \varepsilon \qquad 0 \leq \mathrm{PD} \leq \omega \leq 1 \tag{6}$$

where ϕ is the opportunity cost of debt. The random term ε reflects uncertainty in future costs and availability of credit.

Default Probability Model

The default probability affects the cost and availability of debt. Most of the default probability models are based on the application of statistical classification techniques to the relevant loan customer attributes in order to assign them to various risk groups, reflecting their relative creditworthiness (Chhikara, 1989). As a major parametric classification technique, logistic model is often used in the literature. As the default probability threshold is limited to ω by banks, the model form is specified as:

$$PD = \frac{e^{x\beta}}{1 + e^{x\beta}} \tag{7}$$

where x is a vector of factors representing the farm's characteristics, and β is a vector of coefficients.

The credit evaluation literature suggests five traditional characteristics that affect farmers' creditworthiness, which are five C's: Capacity, Capital, Collateral, Character, and Conditions. Capacity refers to a borrower's ability to repay a loan obligation which is often proxied with performance.

[4] In general, the maximum risk level banks can bear is exogenous to farmers. It depends on banks' efficiency, risk management level, and asset adequacy rate and so forth.

Capital is gauged by a firm's capital composition or financial position with an emphasis on risk ratios (e.g. capital structure). Collateral is the level of assets securing a loan. Character relates to borrowers' personal/demographic characteristics. Conditions reflect general economic environment that affect a borrower's ability to repay. Sonka, Dixon, and Jones (1980) conclude lenders are responsive to the borrower's financial position in terms of the amount of the loan approved. Barry et al. (2000) consider three factors in credit analysis: repayment potential, expected returns and risk-bearing ability. When evaluating the creditworthiness of a borrower, agricultural lenders focus on relatively few variables (Gustafson, 1989). In our study, we include three financial indicators and four characteristics in the model. They are leverage ratio (δ), tangible asset ratio (Tang), profitability (r_0), farm size (Size), involvement of family member (Fami), non-farm income (Nfi) and legal organizational form of farm (Form). Then

(8) $$x\beta = \beta_1\delta + \beta_2 Tang + \beta_3 r_0 + \beta_4 Size + \beta_5 Fami + \beta_6 Nfi + \beta_7 Form$$

Leverage ratio is a measure of capital composition. A priori, it is positively related to credit risk (i.e., β_1>0) as high leverage deceases the net value of the farm and increases the difficulty of repayment. Tangible ratio is a measure of collateral and, obviously, is inversely related to the probability of default (β_2<0). Profitability is a good measure of capacity. Higher profitability implies higher capacity to repay the loan and interest (β_3<0). Farm size is considered as a proxy for agency cost between farm proprietors and banks. Large farms are more closely watched by lenders and have larger bankruptcy cost, which would discourage farmers' willingness to default. Consequently, a negative effect of farm size on default probability is expected (β_4<0). The degree of family members' involvement in the business presumably influences the farmer's risk perception. More family participation may make farmers more careful with the decision making and make them more motivated to run the business efficiently in order to have a secure livelihood for the whole family ($\beta_5 < 0$). Non-farm income serves as buffer for farm income loss and can increase farmers' debt service ability and therefore reduce the credit risk ($\beta_6 < 0$). Lenders also judge farmers' credit risk based on the legal status of farm. In contrast to limited liability of corporate firms, family farms are most organized as sole proprietorship and assume full liability. Even in limited partnership form, at least one of partners has to have full responsibility for liability.

After the PD model is substituted back into the cost of debt model, the cost of debt is a function of a set of farm/operator attributes:

(9) $$u_D = \frac{\emptyset(1 + e^{x\beta})}{\omega + (\omega - 1)e^{x\beta}} + \varepsilon$$

Utility Maximization Model

Costs of borrowing include a random element ε which reflects risks from exogenous random shocks. The expected cost of debt is

(10) $$E(u_D) = \frac{\emptyset(1 + e^{x\beta})}{\omega + (\omega - 1)e^{x\beta}}$$

Assume a variance of σ_i^2 and covariance is $\sigma_{i\tau}$ with the return on assets. The expression for expected utility maximization becomes

(11) $$\max_{\delta} \left\{ \begin{array}{c} [(r_0 u_\tau(1+\delta) - \frac{\emptyset(1 + e^{x\beta})}{\omega + (\omega - 1)e^{x\beta}}\delta)](1-\varphi) + p\varphi(1+\delta) \\ -\frac{1}{2}\rho(1-\varphi)^2[r_0^2(1+\delta)^2\sigma_\tau^2 + \delta^2\sigma_i^2 - 2r_0(1+\delta)\delta\sigma_{i\tau}] \end{array} \right\}$$

$$s.t \qquad e^{x\beta} < \frac{\omega}{1-\omega}$$

Differentiating the new objective function with respect to the leverage ratio results in the following first order condition:

(12) $$\left[r_0 u_\tau - \frac{\emptyset\left(1 + e^{x\beta}\right)}{\omega + (\omega - 1)e^{x\beta}} - \frac{\emptyset e^{x\beta}\beta_1}{[\omega + (\omega - 1)e^{x\beta}]^2}\delta\right](1-\varphi) + p\varphi$$
$$-\rho(1-\varphi)^2(r_0^2\sigma_\tau^2 - r_0\sigma_{i\tau}) - \rho(1-\varphi)^2\delta\left(r_0^2\sigma_\tau^2 - 2r_0\sigma_{i\tau} + \sigma_i^2\right) = 0$$

Define $\sigma^2 = r_0^2\sigma_\tau^2 - 2r_0\sigma_{i\tau} + \sigma_i^2$ and derive the second order condition

(13) $$-\left\{\frac{2\emptyset e^{x\beta}\beta_1}{[\omega + (\omega - 1)e^{x\beta}]^2} + \frac{\emptyset e^{x\beta}\beta_1^2[\omega + (1-\omega)e^{x\beta}]}{[\omega + (\omega - 1)e^{x\beta}]^3}\delta + \rho(1-\varphi)^2\sigma^2\right\} < 0$$

The second derivative is negative when $\beta_1 < 0$, in which case the utility is maximized.

Write the FOC as

$$F(\delta,k) = \left[r_0 u_\tau - \frac{\emptyset(1+e^{x\beta})}{\omega+(\omega-1)e^{x\beta}} - \frac{\emptyset e^{x\beta}\beta_1}{[\omega+(\omega-1)e^{x\beta}]^2}\delta\right](1-\varphi) + p\varphi \\ -\rho(1-\varphi)^2(r_0^2\sigma_\tau^2 - r_0\sigma_{i\tau}) - \rho(1-\varphi)^2\delta\sigma^2 \quad (14)$$

where *k* represents all the determinants $(x, p, \rho, r_0, u_\tau, \sigma_\tau^2, \sigma_{i\tau}, \sigma_i^2)$ that influence leverage. When the FOC holds, deriving and rearranging the total differential of (14) yield $\frac{d\delta}{dk} = -\frac{\partial F/\partial k}{\partial F/\partial\delta}$. Since less than zero, the effect of attributes on leverage is determined by the sign of $\partial F/\partial k$.

Comparative static properties of the first order condition are

$$\frac{d\delta}{du_\tau} = -\frac{r_0(1-\varphi)}{\partial F/\partial\delta} > 0 \quad (15)$$

$$\frac{d\delta}{dp} = -\frac{\varphi}{\partial F/\partial\delta} > 0 \quad (16)$$

$$\frac{d\delta}{d\rho} = -\frac{(1-\varphi)^2(r_0^2\sigma_\tau^2 - r_0\sigma_{i\tau}) + (1-\varphi)^2\delta\sigma^2}{\partial F/\partial\delta} < 0 \quad (17)$$

$$\frac{d\delta}{d\sigma_\tau^2} = -\frac{r_0^2\rho(1-\varphi)^2(1+\delta)}{\partial F/\partial\delta} < 0 \quad (18)$$

When default probability approaches zero (i.e., $e^{x\beta} = 0$), the first term in the denominator drops out. This special case coincides with Collins-Barry model in which farmers are assumed to face a constant cost of debt and have full access to credit. Note that the optimal leverage ratio is an increasing function of u_τ and p and a decreasing function of ρ, σ_τ^2, which is consistent with Collins-Barry's conclusion. But in our generalized model, we observe that the effects are changing with the leverage level.

A result of special interest concerns the effect of the growth index, u_τ, an indicator of farms' growth potential. The result suggests that farms with more growth potential tend to borrow more. The signs of the effect of depreciation, risk attitude, and volatility of the profit index are all consistent with the Collins-Barry model.

Further differentiating equations (15) and (16) with respect to leverage suggests that the positive effects of the growth index and the depreciation rate diminish with the increase of leverage level, which is reasonable given the reduced debt capacity in highly leveraged firms. Differentiating $\frac{d\delta}{d\rho}$ and $\frac{d\delta}{d\sigma_\tau^2}$ with respect to the leverage does not provide an unambiguous interpretation.

Different from the Collins-Barry model, the generalized model introduced more determinants. Their effects on capital structure choice are reflected in the following:

Assume $\theta = \frac{[(\beta_1\delta+1)\omega+(\beta_1\delta-1)(1-\omega)e^{x\beta}]}{[\omega+(\omega-1)e^{x\beta}]^3}$, which is greater than zero, because $e^{x\beta} < \frac{\omega}{1-\omega}$.

(19) $$\frac{d\delta}{dSize} = (1-\varphi)\frac{\phi e^{x\beta}\beta_4}{\partial F/\partial\delta}\theta > 0$$

(20) $$\frac{d\delta}{dTang} = (1-\varphi)\frac{\phi e^{x\beta}\beta_2}{\partial F/\partial\delta}\theta > 0$$

(21) $$\frac{d\delta}{dFami} = (1-\varphi)\frac{\phi e^{x\beta}\beta_5}{\partial F/\partial\delta}\theta > 0$$

(22) $$\frac{d\delta}{dNfi} = (1-\varphi)\frac{\phi e^{x\beta}\beta_6}{\partial F/\partial\delta}\theta > 0$$

(23) $$\frac{d\delta}{dForm} = (1-\varphi)\frac{\phi e^{x\beta}\beta_7}{\partial F/\partial\delta}\theta < 0$$

The effects of tangible asset ratio, farm size, family involvement, non-farm income, and organizational form depend on the sign of their respective coefficients β. In general, the ones that increase the default probability would decrease borrowing, such as the effect of farms' legal form, whereas the ones that decrease the default probability would increase the borrowing, which include tangible asset ratio, farm size, family involvement, and non-farm income.

We further investigate the impact of leverage on the effects displayed in (19) through (23) by differentiating the expressions with respect to leverage ratio, δ. Results show that the effects of tangible asset ratio, farm size, family involvement, and non-farm income on capital structure all turn larger on farms with higher leverage, whereas the effect of the legal form diminishes from sole proprietorship to partnership and to corporations. Because of the conflict of interests between the borrower (stockholders) and the lender (bondholders), there exist agency costs of debt. In farms with high leverage, the agency cost of debt is substantially higher than that of lower leveraged farms. Large farms have higher bankruptcy cost. Consequently, their interests are more aligned with lenders. Therefore, the size effect is more prominent at higher levered farms. The tangible asset effect gets higher when leverage increases, which suggests lenders get more cautious with lending and put more emphasis on collateral. Likewise, when dealing with farms with higher leverage, lenders pay more attention to factors such as family involvement and non-farm income that can help reduce the default probability, which means the effect of these factors would increase. However, when the debt servicing obligation decreases as from sole proprietorship to corporations, lenders are increasingly unwilling to grant debt when leverage gets higher.

So far we have shown the theoretical impacts of all attributes (except profitability) on the capital structure and the relative importance of the attributes at different ranges of leverage. The analysis becomes more complicated.

We found that the relationship between profitability and leverage is not unambiguous in the model. The comparative static relationship is reflected in the following expression:

$$(24) \qquad \frac{d\delta}{dr_0} = -\frac{\left[u_\tau - \theta\phi e^{x\beta}\beta_3\right](1-\varphi) - [2r_0(1+\delta)\sigma_\tau^2 - (1+2\delta)\sigma_{i\tau}]\rho(1-\varphi)^2}{\partial F/\partial\delta}$$

In the literature the relationship between capital structure and profitability has long been under debate, with unresolved theoretical controversy, and no clear-cut conclusions have been drawn to date. According to the pecking order theory, more profitable firms tend to have less debt as firms prefer internal financing. All things being equal, the more profitable farms are, the more internal financial resources they have, and therefore one would expect a negative relationship between leverage and profitability. But in the trade-off theory framework, an opposite conclusion is expected because expected bankruptcy costs decline when profitability increases and the deductibility of interest payments induces more profitable firms to use more debt. In our model, the complicated relationship becomes clear in the comparative static analysis.

Though the sign is indeterminate, we can see that it has certain correlation with the leverage level. The literature suggests that, in general, the covariance of business risk and financial risk is not strongly positive and sometime even negative. For simplicity, assume covariance is zero. Then we can see the sign depends on the range of leverage. In the numerator of (24), the negative effects of profitability on leverage rise with leverage, and there exists a cut-off point at which the sign of the whole expression of (24) becomes negative. This means at high range of leverage, more profitable firms tend to borrow less, which is consistent with the hypothesis that farms with more credit constraint will adhere more closely to the pecking order (Barry, Bierlen and Sotomayor, 2000). Below the cut-off point (i.e., when leverage is low enough), higher profitability will induce farmers to borrow more in order to reap the benefit of the tax shield from interest cost, as the agent costs and the probability of bankruptcy are low.

Empirical Model

In the empirical work, we propose to use observed variables to proxy unobservable determinants. We use two indicators to measure risk-averse attribute. They are the age of the farmer (Age), and farmer's education level (Edu). Generally, older farmers have higher risk aversion. The life circle theory suggests that the life circle of farmers parallels the life circle of the family farm. Older farmers generally are in the farm consolidation or exit phase, in which case they are more conservative in management and investment. Meanwhile, older farmer would have stable relationship with banks and are less constrained in credit. Lower education level is usually associated with increased risk aversion, which may be due to the lack of the judgment. Rosen et al. (2003) suggest that education increases the willingness to take risk. We use the total asset growth index as the indicator of the growth attribute, the standard deviation of the ratio of EBITD over total assets as the indicator of volatility.

A generalized linear model is specified as follows:

(25) $$y_{it} = c + \sum_{91}^{99} c_t\, Dyear_{it} + \alpha_1 Age_{it} + \alpha_2 Edu_{it} + \alpha_3 Grow_{it} + \alpha_4 Pro_{it-1} + \alpha_5 Vol_{it-1} + \alpha_6 Dep_{it} + \alpha_7 Size_{it} + \alpha_8 Tang_{it} + \alpha_9 Fami_{it} + \alpha_{10} Nfi_{it} + \alpha_{11} Form_{it} + \eta_i + e_{it}$$

where y denotes the ratio of debt to equity; Dyear denotes year dummy, which is used to capture the year-specific effect; Age denotes the age of farmer; Edu denotes discrete variable of education level (1 for primary school, 2 for non-agri education, 3 for vocational education in agriculture, 4 for higher education in agriculture), Grow denotes the growth index; Pro denotes the previous EBITD over total assets; Vol is the standard deviation of profitability; Dep denotes the ratio of total depreciation to total assets; Size denotes the natural logarithm of farm size;, Tang denotes the ratio of fixed assets to total assets; Fami denotes number of family members participating in the business; Nfi represents the natural logarithm of non-farm income; Form denotes dummy legal status of farm (1 for sole proprietorship, 2 for partnership, 3 for firm form), and η_i is the farm-specific effect or heterogeneity, and e_{it} is disturbance, assumed to be identically and independently distributed. c, c_t, α are parameters to be estimated.

Data

The data used in the application are farm accountancy data (from the Dutch Agricultural Economics Research Institute) of cash crop farms in the Netherlands. Panel data are available over the period 1990-1999 from 450 farms with 2521 observations. Summary statistics of data used in the estimation of model (1) are presented in table 1. The mean value of debt-equity ratio is 0.581 and its median is 0.300, which shows that the distribution of leverage is positively skewed. The long right tail suggests existence of outliers with abnormally high leverage. The average farmers' age is approximately 49, with minimum age 22 and maximum 83. In the sample, the majority of farms are sole proprietorship and corporations only account for less than 4%. Average family members except farm head hired in the farm are less than 1 person, which suggests most of farms do not have family involvement. In the sample period, average profit rate is less than 2%, which indicates poor financial performance. The average growth index is 1.05. If excluding the inflation factor, most farms have the negative growth, which is consistent with what is implied by profitability.

Estimation

Instead of using ordinary least square estimation, we estimate the econometric model with the conditional quantile regression estimator developed by Koenker and Basset (1978). Two reasons motivate use of quantile regression. First, quantile regression is robust to non-Gaussian error distribution, especially fat-tailed situation like the one in our sample. The extreme sensitivity of the least squares estimator to modest amounts of outlier contamination makes it a very poor estimator in many non-Gaussian distributions (Koenker and Basset, 1978). Relying on an ordered set of sample observations and minimizing the function of absolute residuals, conditional quantile model reduces the impact of the outliers. So it is more typical than conditional mean model for asymmetric situation of dependent variable. As we have stated before, the sample distribution of leverage ratio is highly skewed with a long tail. The sample coefficients of skewness and kurtosis of the variable are 25.5 and 868.6, respectively. Both are significantly different from the population values for the normal distribution, 0 and 3, at the 5% confidence level. Second and most importantly, unlike OLS, conditional quantile regression traces the entire distribution of dependent variable conditional on a set of explanatory variables. It has been recognized that the resulting estimates of various effects on the conditional mean are not necessarily indicative of the size and nature of these effects on different quantile of the distribution, such as the lower tail (Koenker and Basset, 1978). Conditional quantile regression can indicate the different effect of covariate on dependent variable under its different range. In our theoretical model, we have derived that the effects of determinants on leverage ratio change with the magnitude of leverage ratio. Therefore, quantile regression is very appropriate to test our theoretical hypotheses.

In panel data models, treatment of heterogeneity across farms is one of the major concerns. Heterogeneity may result from differences in geographical locations, management capabilities, and motivations, etc. The individual effect η_i in model (25) renders the ordinary least squares estimator inconsistent if it correlates with regressors. Fixed effects estimation allows for correlation between the unobserved effect and the observed explanatory variables, and is more robust than random effects estimation. However, the robustness comes at a price: we cannot include time-constant factors in explanatory variables. In our study, time-constant factors, such that farm's legal status, are also of our interest. So the traditional within estimator or difference estimator is not suitable[5].

We use Mundlak (1978) and Chamberlain (1982) approach to estimate the quantile regression model. We allowed for correlation between η_i and z_{it}. Rewrite model in (25) as:

(26) $$y_{it} = c + \sum_{91}^{99} c_t \, Dyear + \pi_1 z_{1i} + \pi_2 z_{2it} + \eta_i + e_{it}$$

where z_{1i} are time-constant variables and z_{2it} is time-variant variables, which include Grow, Pro, Dep, Size, Tang, and Nfi.

A Mundlak-Chamberlain approach specifies heterogeneity as a linear function of $\bar{z}_{2i}$, the mean of z_{2it}.

(27) $$\eta_i = b + \bar{z}_{2i}\lambda + \xi_i$$

Combining (26) and (27) yields

(28) $$y_{it} = c + \sum_{91}^{99} c_t \, Dyear + \pi_1 z_{1i} + \pi_2 z_{2it} + \bar{z}_{2i}\lambda + \xi_i + e_{it}$$

where $\zeta_{it} = \xi_i + e_{it}$ is not correlated with z_i, but exhibits serial correlation due to ξ_i.

In the quantile regression, we use the bootstrap method to estimate the covariance matrix of the parameter vector and construct confidence intervals.

Results

Table 2 reports the results of estimating equation (4) at nine quantiles, namely, 10th, 20th, 30th, 40th, 50th, 60th, 70th, 80th, and 90th quantiles, using the same list of explanatory variables for each of these quantiles. F-values for all coefficients of $\bar{z}_{2i}$ in the estimate show that the correlation of heterogeneity and regressors cannot be rejected at 5% significant level.

[5] Although time-constant variables cannot be included by themselves in the fixed effects model, one can interact them with variables that change over time – for example with time period dummy variables. Doing so will estimate how the partial effect of that variable changes over time. Since the model is involved in many time-constant variables, this way of identifying the effect of time-constant variables is not adopted.

As a proxy for risk aversion, education has a significant, positive effect on leverage only at low quantile of the distribution, and the effect increases, but is insignificant when moving up to higher leverage level, suggesting that the empirical result is consistent with the theoretical inference. Age has a significant, negative coefficient throughout the distribution. The magnitude increases when moving up the leverage range.

As expected, the growth potential has a significant, positive coefficient across most of the distribution. However, the size of the coefficient increases (rather than decreases) with the leverage. The increasing positive effect may arise from its effect on default probability.

The profitability has no effect at low level of leverage, and it becomes negative and significant at the medium and high quantiles of the distribution (Figure 2 in Appendix). Furthermore, the effect substantially magnifies. It verifies our theoretical inference about the effect of profitability on leverage: farmers with higher leverage prefer internal financing, providing support for the pecking order theory. At the highest quantiles of the distribution, leverage ratio is very sensitive to profitability. The coefficients of previous profitability are -1.3 on the 90^{th} quantile. Generally, farmers with such high leverage have been blocked out the credit market and issuing more debt is not feasible. Income generated by operation becomes the only source of financing.

The effects of depreciation rate are mixed and insignificant over the majority of the distribution. We find the effect of farm size is positive for farms in the lower and upper ranges of the leverage, which is consistent with the view that larger size reduces default probability. We also find the effect of farm size on leverage is increasing when moving up the leverage, which is also expected.

The impacts of tangible assets on the farm's capital structure choice vary in size and significance as leverage moves up. The effect is positive and significant at the low and medium quantiles, but the effect decreases and becomes insignificant, and then the sign becomes negative at the highest quantile. This may suggest that as farms become highly leveraged, they are no longer able to borrow by collateralizing fixed assets. This is consistent with the argument by Stiglitz and Weiss (1981) that there is an adverse selection effect in which case the collateral no longer provides credible security for lenders, because borrowers are seeking riskier strategies.

Non-farm income has no significant effect on leverage at all quantiles of the distribution, even though the sign is largely consistent with the expectation. The effect of legal status of farms on leverage is negative only in the low range of the leverage distribution and has the expected sign. Family involvement has a significant positive effect, but only in low ranges of leverage.

The estimated coefficients on time dummies suggest insignificant effects of macroeconomic variables. The results from this study do not provide support for the effect of volatility on leverage, presumably due to the fact that data used are from single-industry, specialized operation where business risk does not have sufficient variation.

Conclusions

This study proposed a theoretical framework for analyzing farm capital structure choice. The theoretical model recognizes that the costs of debt are endogenously determined which in turn reflect the degree of credit constraint faced by individual borrowers. Based on the theoretical framework, we derived the impacts of different factors on capital structure choice analytically. The theoretical results further suggest that the potential determinants of capital structure have differing effects at different ranges of leverage. The determinants analyzed include farmers' risk attitude, growth potential, profitability, volatility, farm size, the age of farmers, tangible assets, family involvement, non-farm income, and legal status of farms.

Methodologically, we proposed a fixed-effect quantile regression procedure to estimate the impacts of different determinants at different ranges of leverage. The theoretical inferences are tested with empirical data and the results are analyzed. We found that risk attitude, grow potential, farm size have significant effects on farm capital structure choice at almost all leverage levels, while tangible assets, profitability, the legal form, and family involvement only exhibits influences over certain ranges. In particular, profitability negatively impacts leverage in high levels of leverage, suggesting the pecking order theory dominates the trade-off theory. Most of the empirical evidence found in this study is consistent with the theoretical model. However, our empirical results do not provide support for the effect of volatility due to the single-industry nature of the data used.

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Table 1. Summary statistics of Dutch Arable Farms 1990-99

	Unit	Mean	Std. Dev.	Min	Max
Leverage	Ratio	0.581	1.923	0.000	76.027
Age	Years	48.612	10.427	22.000	83.000
Edu	Dummy	2.309	0.608	1.000	4.000
Grow	Ratio	1.050	0.242	0.474	6.898
Pro	Ratio	0.013	0.100	-1.716	0.395
Vol	Standard deviation	0.037	0.039	0.000	0.674
Dep	Ratio	0.034	0.021	0.001	0.170
Size	The nature logarithm	4.401	0.640	2.659	6.270
Tang	Ratio	0.663	0.185	0.032	0.956
Fami	Integer	0.628	0.868	0.000	10.000
Nfi	The nature logarithm	10.083	1.009	2.485	12.686
Form	Dummy	1.359	0.488	1.000	3.000

Table 2. Results from Quantile Regression

	10th quantile		20th quantile		30th quantile	
Var.	Coe.	p-value	Coe.	p-value	Coe.	p-value
Age	-0.001***	0.001	-0.004***	0.000	-0.005***	0.000
Form	-0.026***	0.000	-0.022***	0.009	-0.019	0.185
Edu	0.007*	0.069	0.011*	0.053	0.010	0.187
Fami	0.005	0.277	0.012*	0.058	0.019***	0.006
Nfi	0.001	0.926	0.002	0.893	0.007	0.671
Grow	0.070	0.161	0.078*	0.069	0.076	0.356
Size	0.031***	0.003	0.032**	0.041	0.027	0.143
Tang	0.209***	0.001	0.331***	0.000	0.350***	0.000
Vol	-0.086	0.383	-0.329	0.106	-0.299	0.304
Dep	-0.852	0.126	-1.043	0.181	-1.780	0.192
Pro	-0.150	0.143	-0.151	0.149	-0.284**	0.044
d91	-0.002	0.893	0.001	0.936	0.001	0.944
d92	-0.004	0.779	-0.004	0.852	-0.016	0.425
d93	0.004	0.761	-0.004	0.850	-0.015	0.509
d94	0.011	0.359	0.015	0.514	0.011	0.596
d95	0.002	0.920	-0.015	0.465	-0.024	0.261
d96	0.006	0.570	-0.006	0.747	-0.020	0.375
d97	0.010	0.263	0.011	0.591	-0.002	0.935
d98	0.010	0.487	0.003	0.894	-0.010	0.648
d99	0.002	0.838	-0.011	0.635	-0.024	0.217
anfi	0.002	0.850	0.007	0.713	0.001	0.946
agrow	0.034	0.532	0.094	0.286	0.147***	0.008
asize	0.000	0.629	0.000	0.291	0.000	0.108
atang	-0.068	0.327	-0.059	0.485	-0.044	0.594
apro	-0.097	0.593	-0.301**	0.044	-0.169	0.452
adep	1.523***	0.004	2.819***	0.003	4.349***	0.007
_cons	-0.273***	0.005	-0.363***	0.006	-0.327**	0.053

(Continued)

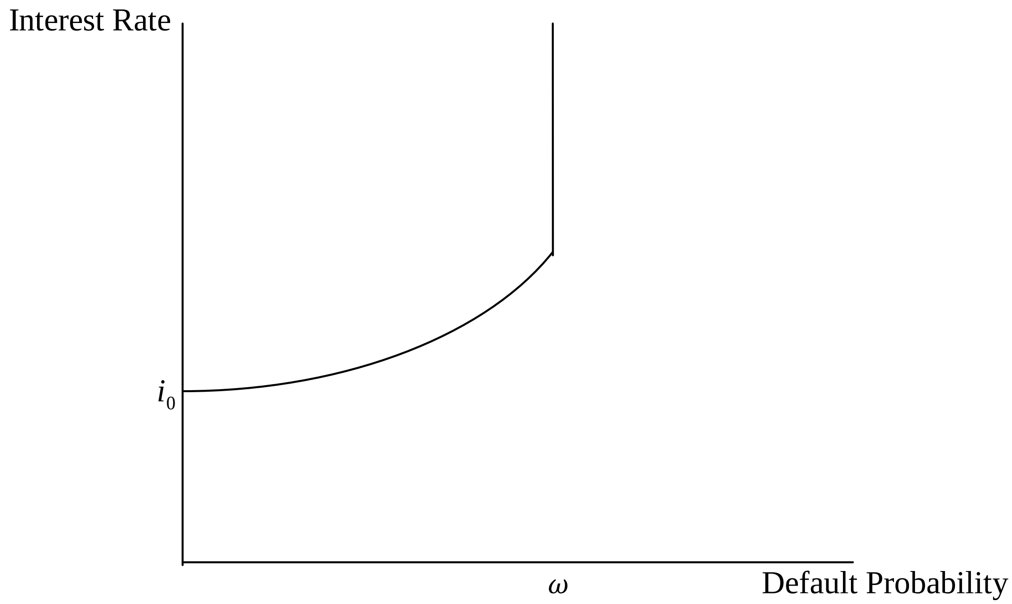
	40th quantile		50th quantile		60th quantile	
Var.	Coe.	p-value	Coe.	p-value	Coe.	p-value
Age	-0.006***	0.000	-0.009***	0.000	-0.011***	0.000
Form	-0.033**	0.041	-0.046**	0.029	-0.037	0.209
Edu	0.009	0.329	0.006	0.555	0.009	0.550
Fami	0.022***	0.010	0.012	0.339	0.011	0.405
Nfi	-0.011	0.602	0.006	0.799	-0.017	0.587
Grow	0.274***	0.009	0.324***	0.000	0.446***	0.000
Size	0.039	0.202	0.037	0.175	0.106***	0.000
Tang	0.332***	0.005	0.318**	0.038	0.279	0.132
Vol	-0.393	0.354	-0.144	0.720	0.005	0.993
Dep	-4.467**	0.036	-4.508**	0.026	-3.387	0.213
Pro	-0.607***	0.004	-0.843***	0.003	-1.391***	0.000
d91	-0.001	0.958	-0.005	0.824	-0.004	0.856
d92	-0.014	0.623	-0.002	0.956	-0.011	0.691
d93	0.005	0.877	0.040	0.214	0.007	0.856
d94	0.022	0.495	0.052*	0.077	0.041	0.262
d95	-0.026	0.419	-0.001	0.977	-0.016	0.619
d96	-0.015	0.607	0.009	0.793	0.004	0.924
d97	0.001	0.974	0.036	0.353	0.039	0.237
d98	-0.014	0.672	0.003	0.917	0.012	0.767
d99	-0.023	0.401	0.004	0.887	-0.018	0.502
anfi	0.027	0.283	0.007	0.810	0.039	0.244
agrow	0.105	0.336	0.124	0.286	0.026	0.863
asize	0.001**	0.085	0.001**	0.012	0.001**	0.048
atang	0.037	0.782	0.048	0.775	0.063	0.749
apro	-0.095	0.780	-0.033	0.944	0.316	0.460
adep	8.423***	0.001	8.798***	0.000	8.486***	0.002
_cons	-0.563**	0.042	-0.427	0.106	-0.661***	0.003

(Continued)

	70th quantile		80th quantile		90th quantile	
Var.	Coe.	p-value	Coe.	p-value	Coe.	p-value
Age	-0.014***	0.000	-0.013***	0.000	-0.019***	0.000
Form	-0.031	0.259	-0.015	0.695	0.060	0.419
Edu	0.002	0.902	0.020	0.406	0.026	0.654
Fami	0.002	0.882	0.005	0.717	-0.053	0.159
Nfi	-0.006	0.820	0.013	0.718	0.134	0.193
Grow	0.531***	0.000	0.559***	0.000	0.830***	0.002
Size	0.139***	0.000	0.122**	0.023	0.303**	0.022
Tang	0.185	0.445	0.054	0.906	-0.236	0.788
Vol	0.123	0.868	1.016	0.394	3.809*	0.094
Dep	0.327	0.942	4.820	0.400	24.970**	0.020
Pro	-1.573***	0.000	-1.287**	0.011	-1.837	0.323
d91	-0.025	0.500	-0.014	0.781	-0.027	0.853
d92	0.003	0.957	0.036	0.665	0.109	0.604
d93	0.002	0.948	-0.038	0.590	-0.013	0.958
d94	0.023	0.623	-0.050	0.470	0.066	0.721
d95	-0.034	0.502	-0.038	0.565	0.015	0.942
d96	0.003	0.953	0.001	0.994	-0.012	0.948
d97	0.040	0.344	0.046	0.395	0.026	0.897
d98	0.003	0.956	-0.035	0.456	-0.035	0.832
d99	-0.015	0.656	-0.033	0.569	0.019	0.920
anfi	0.060**	0.042	0.083**	0.034	0.018	0.877
agrow	0.148	0.302	0.134	0.528	-0.312	0.594
asize	0.000	0.262	0.000	0.531	-0.001	0.220
atang	0.165	0.529	0.297	0.542	0.301	0.740
apro	-0.022	0.963	0.067	0.909	0.195	0.917
adep	6.550	0.178	6.874	0.257	-9.371	0.359
_cons	-1.084***	0.000	-1.547***	0.000	-1.980**	0.028

Note: Single (*), double (**) and triple (***) asterisks denote statistical significance at10%, 5%, and 1%, respectively.

Figure 1. Interest Rate Faced by Farmers



Figures 2. Estimated Coefficient Distribution