KNOWLEDGE CAPITAL, INTANGIBLE ASSETS, AND LEVERAGE: EVIDENCE FROM U.S. AGRICULTURAL BIOTECHNOLOGY FIRMS

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ABSTRACT

Firms in general, and high technology firms such as biotechnology firms in particular, are both a set of assets in place and growth opportunities. This has important implications for managerial decision-making. Knowledge capital motivates exploitation of growth options, which affects firm cash flow. In turn, the level and volatility of firm cash flow influences firm financing decisions. Previous studies suggest that knowledge capital can influence both the location and capital structure of firms in the biotechnology industry. However, the empirical analyses have not extended to agricultural biotechnology firms. The research reported here is motivated by a desire to understand the role of knowledge capital and other intangible assets in capital structure decisions of U.S. agricultural biotechnology firms. Quantitative results indicate that leverage is negatively related to growth and non-debt tax shields. Asset tangibility, size, profitability, and uniqueness are positively related to leverage. Depending on the metric employed for leverage, the empirical models explain up to approximately 75% of the variation in leverage. Estimates of elasticities reinforce the importance of intangible assets such as knowledge capital and tax shields in capital structure choice and add a significant new component to understanding the financial management decisions of agricultural biotechnology firms.

Keywords: Capital structure, agricultural biotechnology, knowledge capital, intangible assets
JEL codes: G32, Q13, and Q14

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Introduction

Technological advances, better management practices, and improved production inputs are driving forces behind the substantial productivity gains experienced by the U.S. agricultural sector. Agricultural biotechnology plays an integral role, and as such, has profoundly influenced the face of U.S. farming, food processing, and food consumption. Agricultural biotechnology firms participate in a food system where rivalry continues to shift from tangible to intangible assets such as knowledge capital. This situation provides impetus for attempts to better understand the financial management aspects of agricultural biotechnology firms.

Biotechnology firms are characteristic of high technology companies. Firms in general, and high technology firms in particular, are both a set of assets in place and growth opportunities (Myers, 1977; Myers and Majluf, 1984; Rajan and Zingales, 1995). Liu (2001) reminds us that the "essence of a firm in the new economy is its ability to create, transfer, assemble, integrate, protect, and exploit knowledge capital. Knowledge capital underpins competences, and competences underpin the firm's product and service offering to the market" (Liu, 2001, p. 1). This has important implications for managerial decision-making. Knowledge capital motivates exploitation of growth options which affects firm cash flow. In turn, the level and volatility of firm cash flow fundamentally influences firm financing decisions.

Capital structure of firms has received extensive theoretical and empirical attention, including the role of intangible assets on optimal leverage (e.g., Rajan and Zingales, 1995). A recent study explores the characteristics and growth of U.S. biotechnology firms (Zucker, Darby, and Brewer, 1998). Their findings reveal a connection between the location and growth of intellectual capital and that of U.S. biotechnology firms. It is apparent from these studies that knowledge capital can influence both the location and capital structure of biotechnology firms. Liu (2001) studied the interaction among biotechnology firms' knowledge capital, growth opportunities, earnings dynamics, and optimal leverage. Results suggest that investments in research and development and knowledge capital are related to leverage. However, the empirical analysis has not extended to agricultural biotechnology firms.

The research reported in this manuscript is motivated by a desire to understand the role of knowledge capital and other intangible assets in capital structure decisions of U.S. agricultural biotechnology firms. The objective is to better understand the role that knowledge capital and other intangible assets have on their debt versus equity financing decisions.

Several categories of firms operate in the agricultural biotechnology industry. Dedicated biotechnology companies (DBCs) are those firms primarily engaged in biotechnology research activities and are often small, private, start-up companies early in their life cycle (Sporleder, 1999). Smaller DBCs often develop "platform technologies" that position the firm for merger, acquisition, or initial public offering. Though innovative, they typically lack the financial or human capital necessary to fund developmental research and commercialize new products. Strategic partnering with larger major corporations with complementary business assets can result. Second, certain major corporations have significant investments in biotechnology though their revenue stream is not fundamentally dependent upon biotechnology-based products or services. Pharmaceutical companies are a third firm type but are primarily oriented toward the human health market rather than toward food or agriculture. The focus of this study is on U.S.-based DBCs.

The remainder of the paper is organized as follows. Background and a brief literature review are presented first, followed by a description of the data and empirical model, and a discussion of the results derived from it. The paper ends with some conclusions and suggestions for additional research.

Previous Studies on Capital Structure

The capital structure literature has become well developed over the past four decades. [2] More recently, knowledge is increasingly becoming recognized as both a strategic and valuable asset of a firm, and its management is emerging as a potential source of competitive advantage in contemporary analyses (Connor and Prahalad, 2002; Grant, 2002; Hudson, 1993; Morey, Maybury, and Thuraisingham, 2000; Nonaka and Takeuchi, 1995). Using the logic of the various strains of capital structure theory, one may conclude that industries or firms with a large proportion of knowledge assets should be less levered in that these assets are less redeployable and may have lower liquidation value. However, the interaction among knowledge capital and capital structure largely remains an unanswered theoretical and empirical question, particularly for agricultural biotechnology firms.

[2] For a comprehensive survey of the literature, see Harris and Raviv (1991).

In their study of 751 biotechnology firms Zucker, Darby and Brewer (1998) found that both DBC start-ups and expansion subsidiaries of incumbent firms locate around intellectual human capital, namely "star" scientists who are significant contributors to the basic science. They also explored the role of venture capital in location choice since the availability of venture capital funding is believed to play a vital role in new firm entry (Lerner, 1995). The number of star scientists, top-quality universities, faculty with federal support and venture capital firms are positive and statistically significant predictors of both the stock value of biotechnology firms operating in a region and the number of new start-ups. Interestingly, venture capital firms had a strong positive effect only when other measures of intellectual human capital (i.e., universities, star scientists and federal funding) were eliminated from the model. The presence of venture capital firms may actually mirror and therefore proxy for more direct measures of intellectual capital in that these firms tend to develop around the scientists and institutions that they serve.

A recent study explores the interaction among U.S. biotechnology firms' knowledge capital, growth options, earnings, and capital structure (Liu, 2001). The author's theoretical model suggests a positive relationship among knowledge capital and leverage, which contrasts with most previous studies. Additionally, this study is the first to apply several classical determinants of capital structure to biotechnology firms.

One study has investigated empirically the role of intellectual capital and venture capital financing on the location choice of agricultural biotechnology firms (Sporleder, Moss, and Nickles, 2002). It suggests that the location choice by state of agricultural DBCs is determined primarily by R&D funding.[3] Total R&D funding per million people can proxy for the general intellectual human capital of a region as evidenced through its science and higher educational environment. Venture capital has a positive though statistically insignificant influence on location choice, while the size of the state economy and its dependence on agriculture have negative and statistically insignificant effects. However, what determines the capital structure of agricultural biotechnology firms remains an unexplored empirical question.

Empirical Model of Capital Structure

The determinants of capital structure are explored for publicly traded U.S. agricultural biotechnology firms using COMPUSTAT data. The data set includes 6,671 firm-year observations from 748 firms for the time period 1980 through 2000, where agricultural biotechnology firms are identified by a total of eighteen six-digit NAICS codes.[4] Consistent with previous empirical studies, various measures of firm leverage are considered and contrasted in the analysis. The influence of growth, size, profitability, non-debt tax shields, the uniqueness of the firm's assets, and intangible assets such as knowledge capital are explored using ordinary least squares regression. The capital structure of agricultural

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[3] Agricultural biotechnology start-ups are clustered in California, the Northeast, and the Midwest. Six of the top ten states in terms of number of firms are in the northeastern U.S. Compared to any other state, California accounts for the largest amount of both venture capital and start-ups (Sporleder, Moss, and Nickles, 2002).

[4] The North American Industry Classification System (NAICS) classifies entities by their type of economic activity. The U.S. Office of Management and Budget adopted it in 1997 to replace the 1987 Standard Industry Classification (SIC) coding system.

biotechnology firms is modeled as follows:

$$LEVER_i = \alpha + \beta_1 TANG_i + \beta_2 NDTS_i + \beta_3 GROW_i + \beta_4 UNIQ_i + \beta_5 SIZE_i + \beta_6 PROFIT_i + \varepsilon_i$$

where;

$LEVER_i$ = Firm leverage, measured as: (i) total debt divided by total assets ("Leverage 1")[5]; (ii) total debt divided by the sum of total debt and common equity (market value) ("Leverage 2"); and (iii) total liabilities divided by total assets ("Leverage 3").

$TANG_i$ = Tangibility of assets (inventory plus gross plant and equipment divided by total assets);

$NDTS_i$ = Non-debt tax shields (operating income less interest expense less tax payments divided by total assets);

$GROW_i$ = Firm growth (percentage change in total assets);

$UNIQ_i$ = Uniqueness of the firm's assets (selling and administrative expenses divided by total assets);

$SIZE_i$ = Firm size (natural logarithm of net sales);

$PROFIT_i$ = Firm profitability (earnings before interest, taxes and depreciation (EBITDA) divided by total assets);

As indicated, three different leverage measures are considered. Leverage 1 measures the ratio of debt used the finance the firm's assets based on book values, while Leverage 2 is

[5] Unless otherwise indicated, all variables are book values.

based on market value. Leverage 3 represents the most expansive definition in that total liabilities include items only indirectly related to financing (e.g., accounts payable). As such, it serves as a proxy for the residual to shareholders upon firm liquidation.

The independent variables are measured in a manner most appropriate in terms of their overall explanatory power for this sample of firms.[6] First, consensus exists that the characteristics of a firm's assets influences its capital structure (e.g., Williamson, 1988; Long and Malitz, 1985; Rajan and Zingales, 1995). Asset tangibility and leverage should be positively related in that tangible assets are both readily collateralized and liquidated or redeployed at market value. High technology firms' knowledge capital is relatively non-redeployable, hence, companies with greater knowledge assets are expected to be less levered.

Financing decisions may be persuaded by the tax benefits of debt, if the firm has enough taxable income to support debt. In contrast, other non-debt tax shields such as investment tax credits, amortization, and depreciation deductions may mitigate this incentive. Empirical studies of the influence of non-debt tax shields on leverage are numerous, though results are conflicting (Bradley, Jarrell and Kim, 1984; Harris and Raviv, 1991; Titman and Wessels, 1988; Banerjee, Heshmati and Wihlborg, 2000). Consistent with recent studies of other publicly traded firms, non-debt tax shields are expected to be negatively related to leverage for agricultural biotechnology firms.

Most of the capital structure literature suggests that growth and leverage are negatively related, though for various reasons. Based on the underinvestment problem

[6] For additional discussion regarding the exploration of the performance of alternate measures of the explanatory variables, see Nickles (2001).

articulated by Myers and Majluf (1984), firms who anticipate a high rate of future growth should rely on a greater degree of equity capital. Or, high growth companies have greater abilities to invest less and, as a result, extract wealth from their shareholders (Titman and Wessels, 1988). Growth can be measured as either the percentage change in total assets from year to year (i.e., actual growth in firm size) or as market-to-book value (i.e., growth opportunities enabled by intangible assets like managerial prowess). The analysis here uses the former measure and a negative relationship between firm growth and leverage is expected.

Uniqueness represents the differences among firms that may result in competitive advantage. Titman and Wessels (1988) argue that firms that provide unique or specialized products or services will experience thinner markets when liquidating with lower asset values recoverable by their lenders. Uniqueness is commonly measured as the ratio of either R&D expenditures or selling and administrative expenses to total assets. Following the literature, uniqueness and the firm's debt ratio should be negatively related. Selling and administrative expenses proxy for uniqueness.

Previous research is divided on the role of firm size and leverage. Larger firms are more diversified and have a lower probability of bankruptcy. They typically have lower costs when issuing debt or equity in comparison to their smaller counterparts. Debt tends to be less expensive for smaller firms in comparison to equity, and as a result, small firms may support higher leverage. However, larger firms possess greater debt carrying capacity suggesting greater leverage ratios. Consistent with previous studies, the natural logarithm of net sales is employed as the size measure. A priori, the relationship among size and leverage for agricultural biotechnology firms in the sample is indeterminant.

Despite different theoretical arguments (e.g., Myers and Majluf, 1984; Titman and Wessels, 1988; and Jensen, 1986), the empirical evidence unambiguously suggests a negative relationship among profitability and firm capital structure. Firms prefer internal to external financing and more profitable firms have more internal capital available. The ratio of net income to total assets is used as a measure of profitability.

Empirical Evidence Regarding Capital Structure

Summary statistics for the model variables are presented in Table 1. Leverage means are distinctly different across the three definitions of leverage considered in this study. The sample displays a wide degree of variability in the explanatory variables of interest. Notably, 52.3 percent of these firms' assets are tangible on average, though the ratio of tangible to total assets ranges from zero to 99.5 percent. On average, these 748 firms are not growing in size and are not profitable at this stage in their life cycles.

Table 2 reports the results of the regression models for each leverage characterization. Consistent with results from previous studies using market value-based characterizations of leverage, the overall performance of the Leverage 2 model is poor. Market values of common equity, particularly during the time period considered in this study, may be driven increasingly by market-related factors (e.g., investor optimism, information) that escape explanation in our model.

The Leverage 1 model, where leverage is measured as the ratio of total debt to total assets, explains about 40 percent of the variation in capital structure. The coefficients behave as anticipated, except growth and profitability. In this model, growth and leverage are positively related which is counterintuitive and inconsistent with the other leverage models considered in this study. This model suggests further that profitability and leverage are positively related, which is an unanticipated result. However, the sign of the profitability variable in consistently positive across all three models for this sample of firms.

Finally, the Leverage 3 model, with leverage measured as the ratio of total liabilities to total assets, explains approximately 75 percent of the variation in capital structure. Moreover, all coefficients are statistically significant at the 1 percent level. In contrast to a priori expectations, uniqueness and leverage are positively related. Firms with more unique products are expected to spend more to advertise and promote their market offerings. However, the metric for uniqueness has some well-documented shortcomings.[7] Thus, minor importance is given to the performance of this indicator in the three models.

The consistently positive relationship between profitability and leverage across all models is puzzling. If firms do in fact follow a pecking order, we expect internal finance to be preferred over debt, which in turn is more favorable to new equity issues. More profitable firms, ceteris paribus, have more available internal capital and can chose to rely less on debt capital. Why do more profitable publicly traded agricultural biotechnology firms use more debt?[8] Perhaps the answer lies in the industry context, in that no previous capital structure studies other than Liu (2001) considered high technology firms alone. Though Liu (2001) found a negative relationship among the profitability of U.S.-based biotechnology firms and their debt ratios, this relationship was generally weak and statistically insignificant. Since

[7]The metric used here can be related to both non-debt tax shields and collateral value. Better metrics continue to be both theoretically and empirically explored (Rajan and Zingales, 1995; Banerjee, Heshmati, and Wihlborg, 2000).

[8] Though not reported here, a regional regression analysis demonstrates that profitability and leverage are in fact negatively related for agricultural biotechnology firms located in the Pacific and Mountain regions (i.e., the western U.S.).

many biotechnology firms are start-ups with little or no operating income, our result may not be surprising.

Elasticity estimates from the Leverage 3 model are presented in Table 3. Both growth and uniqueness influence leverage very little. In contrast, firm size has the largest effect. Every 1 percent increase in firm size results in a 3.3 percent increase in firm leverage. Tangibility and non-debt tax shields have modest elasticities at 0.87 and -0.91, respectively.

The empirical results here are similar to that of Liu. In general, both support debt ratios positively related to knowledge capital measures such as research and development (R&D) investment, in the absence of better measures. Results from Liu suggest that leverage is positively related to firm size and asset tangibility and negatively related to profitability and uniqueness.

Concluding Remarks

Quantitative results indicate that leverage is negatively related to growth and non-debt tax shields. Asset tangibility, size, profitability, and uniqueness are positively related to leverage. Depending on the metric employed for leverage, the empirical models explain up to approximately 75% of the variation in leverage. Estimates of elasticities reinforce the importance of intangible assets such as knowledge capital and tax shields in capital structure choice and add a significant new component to understanding the financial management decisions of agricultural biotechnology firms.

This research is simply a preliminary effort toward integrating knowledge management into the capital structure dialogue for firms in the agriculture and food industry, like agricultural biotechnology firms, for which knowledge capital and intangible assets play an increasingly important component role in competitive advantage. Future research might model and empirically test more precise measures of a firm's knowledge capital. R&D investment, patent data such as citation or claim weighted patent counts, or firm linkages to "star" scientists are promising knowledge capital proxies.[9] Liu (2001) argues that knowledge capital acts as a form of financial collateral for firms. However, the process of knowledge creation is not confined to firm boundaries in that knowledge is shared and enhanced through participation in a social network. Thus the dynamics among investing in components of intellectual capital (i.e, human, structural and social capital; Nahapiet and Goshal, 1998), growth opportunities, earnings dynamics, and capital structure remains an important avenue for future study.

[9] Some argue that R&D expenditure is a less informative measure in that it is input oriented, thereby not capturing the quantity or quality of the firm's research output. Moreover, its effects on leverage may lie more directly in its tax credits.

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Table 1 Summary Statistics for Model Variables

Variable	Mean	S.D.	Maximum	Minimum
LEVERAGE 1	0.1754	0.8514	50.7273	0
LEVERAGE 2	0.2600	2.2305	157.3200	0
LEVERAGE 3	0.7251	4.9180	255.6667	0
TANG	0.5232	1.3929	99.4762	0
NDTS	-0.4040	2.8616	3.0566	-158.6667
GROW	-0.0176	1.8973	1	-106.5000
UNIQ	0.4526	2.5507	154.0000	0
SIZE	2.4026	2.8201	10.6057	-6.9078
PROFIT	-0.3946	2.8196	4.7800	-154.0000

Table 2 Capital Structure of U.S. Agricultural Biotechnology Firms, OLS Regression

Explanatory Variable[a]	LEVERAGE 1 Coefficient Estimate	LEVERAGE 2 Coefficient Estimate	LEVERAGE 3 Coefficient Estimate
Intercept	0.0180 (0.0114)	0.2381*** (0.0385)	-0.6211*** (0.0422)
TANG	0.1606*** (0.0088)	0.0697** (0.0297)	1.2051*** (0.0326)
NDTS	-0.4415*** (0.0212)	-0.1702** (0.0716)	-1.6333*** (0.0786)
GROW	0.0473*** (0.0045)	-0.0027 (0.0153)	-0.1110*** (0.0168)
UNIQ	-0.3764*** (0.0072)	0.0182 (0.0243)	0.1559*** (0.0266)
SIZE	0.0346*** (0.0031)	-0.0065 (0.0103)	0.0625*** (0.0113)
PROFIT	0.0423* (0.0230)	0.1926** (0.0779)	0.4226*** (0.0855)
	Adj. R^2 = 0.4009 F-stat = 744.98 Prob.>F= 0.0000	Adj. R^2 = 0.0010 F-stat = 1.1480 Prob>F = 0.3315	Adj. R^2 = 0.7526 F-stat = 3378.27 Prob>F = 0.0000

[a] Standard errors are in parenthesis. Asterisks indicate significance at the 10% (*), 5% (**), and 1% levels (***), respectively.

Table 3 Elasticity Estimates from the Leverage 3 Model

Variable	Elasticity
TANG	0.8695
NDTS	-0.9100
GROW	-0.0027
UNIQ	0.0973
SIZE	3.3134
PROFIT	0.2300