Human-Capital Intensive Firms: Top-Management Compensation and Capital Structure [1]

Yiming Qian [2]

November, 2001

[1] I have benefitted tremendously from the encouragement and guidance of my advisor Kose John. I am indebted to Matthew Clayton, Hamid Mehran, Marti G. Subrahmanyam, Rangarajan Sundaram and David Yermack for numerous detailed discussions. I thank Heitor Almeida, Yakov Amihud, Jennifer N. Carpenter, Christopher J. Flinn, William Greene, Jay Hartzell, Anthony W. Lynch, Holger M. Müller, Eli Ofek, S. Abraham Ravid, Matthew Richardson and Robert Whitelaw for helpful comments and suggestions. All errors are mine.

[2] Contact: Yiming Qian, Department of Finance, Stern School of Business, New York University, 44 West 4th St., Suite 9-180, New York, NY 10012. Tel: 212–998–0372. Fax: 212–995–4233. e–mail: yqian@stern.nyu.edu.

Human-Capital Intensive Firms: Top-Management Compensation and Capital Structure

Abstract

This paper studies top management compensation and capital structure decisions in human-capital intensive firms and how they differ from those of traditional firms. Incentivizing non-management key personnel through optimally designed contracts is a center issue in human-capital intensive firms. Optimal renegotiation procedures are also specified in the contract to redress potential breach of the contract due to hold up by equityholders. The set of renegotiation-proof contracts are affected by the capital structure and the top management compensation structure. I show that the feasible set of renegotiation-proof contracts is decreasing in the amount of debt in the capital structure. The optimal debt level decreases as the human capital intensity of the firm increases. I also show that the option component in the top management compensation structure should be lower in human-capital intensive firms.

I construct proxies for human-capital intensity and empirically test two hypotheses related to capital structure: (1) there is a negative relationship between leverage and human-capital intensity, *ceteris paribus*; (2) the more specific the firm's assets are, the stronger is this negative relationship. I find strong and robust supporting evidence for both hypotheses.

1 Introduction

Our economy is becoming increasingly based on information and knowledge. Human capital is becoming more and more important in the production process. Rajan and Zingales (2000) argue, "Since then (1930s) the nature of the enterprise has changed greatly: human capital has replaced physical capital as the main source of value." If that is the case, it will inevitably change the power balance between the owners of the human capital and the owners of physical capital. Many business philosophies that were viewed as reasonable and legitimate might have to be reexamined. Finance researchers are therefore facing the new challenge of understanding, interpreting and providing guidelines for corporate decisions in light of human capital concerns.

The subject of this paper is human-capital intensive firms. In these firms, human capital is the most important asset. In contrast to a traditional firm where only top managers' human capital matters, a human-capital intensive firm has broad-based human capital. The group of non-manager key personnel's (in this paper, I call this group the tech workers) human capital is also very important. Some examples of this type of human capital are individual artists in an advertisement firm, each programmer in a software company or all the scientists in a bio tech company.

I investigate how corporate financial policies are affected by the nature of these firms, that is, how their financial policies will differ from those of the traditional firms. In particular, I study the capital structure decisions and top management compensation in human-capital intensive firms. Incentivizing the tech workers by optimally designed contracts is very important in these firms. Due to the incompleteness of contracting, there is a potential ex post hold-up problem between the shareholders and the tech workers. This hold-up problem cannot be solved by ownership integration because of the inalienability of human capital. It therefore leads to an additional constraint on the ex ante renegotiation-proof contracts. Anticipating the potential hold-up problem, the contract will also need to specify a renegotiation form as a redress mechanism. Different renegotiation forms will lead to different contract for the tech workers, which in turn might lead to different human capital supply. I show that capital structure and top management compensation can affect the feasible set of the renegotiation-proof contracts. Debt causes difficulty in incentivizing human capital investment. Therefore it is optimal for human capital intensive firms to borrow less. Options have double-edged incentive implications. Human-capital intensive firms should grant less options to their top management. I empirically test these predictions.

There are two aspects of human capital that are needed by the firm: general human capital which could be transferred from project to project, and/or from firm to firm, and specific human capital to a firm or a project. In the discussion below, I only talk about firm-specific human capital, but most of the story can be applied to project-specific human capital as well. A tech worker carries her general human capital when she joins a new firm. But she needs to build up her specific human capital to be able to contribute to the firm value. The specific human capital is like a bridge between her general human capital and the firms' assets and integrates her with the firm's assets. It will greatly increase her productivity in the firm. Therefore the firm will want to encourage her to make a good investment in specific human capital. Training programs provided by the firm help with the investment. However, the most important investment has to be made by the tech worker herself, which is typically not observable by the others. For example, the fact that an employee is staying in the office does not necessarily mean that she is putting her mind to work. Efforts and the knowledge acquired through effort cannot be measured by time units.

The human capital investment is therefore private to the tech workers themselves. The shareholders cannot write contracts on it or offer to share the expense and opportunity cost. The shareholders, however, can encourage the tech workers to make the investment by promising to share profits. The problem, or, the friction that drives my model, is that after the tech worker has sunk the investment, the shareholders have the incentive and the capacity to withdraw the profit-sharing promise and renegotiate the contract. The ex post hold up problem hurts the incentive of human capital investment. The shareholders are able to hold up the tech workers because the human capital investment is specific to the firm and has little value elsewhere. This is also because the shareholders have discretion on business decisions that affect the realized profits and it is impossible to specify these decisions in the contract ex ante. These decisions are not contractible either because they are too complicated to specify every possibility or because the states of nature decisions should be conditional on are not verifiable. I model one such business decision, the continuation decision, in the paper.

I model a risk-neutral shareholder and risk averse tech worker who supplies human capital. The shareholder and the tech worker will sign a contract ex ante, linking the worker's compensation to the realized cash flow. There is an interim evaluation of the state of nature or economic environment, conditional on which the shareholder will decide whether or not to continue the project. Even if the realized state of nature could be observed by all parties involved, it is not verifiable to a third party such as a court. Therefore contracts conditional on the state of nature are not enforceable, and things are such that unconditional continuation is not optimal. Therefore it is infeasible to write the efficient continuation policies in the contract.

Under some states of the nature, the situation is so bad that the shareholder will close the project for sure. However, even when it is efficient to continue the project, the shareholder can threaten not to continue the project if there is nothing left for her or, the cash flow left for her is not large enough. The shareholder threatens not to continue the project unless the tech worker will take a compensation cut. Anticipating the hold-up problem, the ex ante contract will also specify the renegotiation procedure if bargaining occurs. Each renegotiation procedure corresponds with a bargaining power distribution between the two parties. I only look at renegotiation-proof contracts. The renegotiation-proof compensation structure depends on the renegotiation procedure specified in the contract. That is, the renegotiation procedure determines the payoff to both the shareholder and the tech worker if renegotiation occurs. To make the ex ante contract renegotiation-proof, the implied payoff to the shareholder by the contract cannot be less than what they can obtain by holding up the tech worker. This results in a renegotiation-proof constraint on the optimal contract.

Given a renegotiation procedure specified in the contract, there is an optimal ex ante renegotiation-proof contract. However, the set of optimal renegotiation contracts could be ranked ex ante. I show that the optimal renegotiation form should allow the worker to make a take-it-or-leave-it offer once the shareholders initiate the renegotiation. This renegotiation form gives the tech worker all the bargaining power in event of hold-up. This paper thus experiments to show how bargaining power can be endogenized in the contract.

Capital structure also affects the feasible set of the renegotiation-proof contracts. Under debt financing, the total cash flow available to the shareholder and the tech worker is less. Everything else being equal, debt gives the shareholder more reasons not to continue the project and makes the threat of liquidating the project credible. I show that the feasible set of renegotiation-proof contracts is decreasing in the debt amount. The renegotiation-proof constraint is more and more stringent as the debt increases. The expected compensation therefore increases with debt.

Another way to interpret the above results is that the risk premium needed to provide incentives is higher under debt financing. For a risk-averse tech worker, it is desirable to have as smooth income as possible along the equilibrium paths. The ex post potential hold-up problem puts upper bound restrictions on compensation levels in some states. To satisfy the tech worker's reservation utility, higher compensation levels have to be granted in states where cash flow is rich where a liquidation threat is not credible. Since the upper bound restrictions are more stringent under debt financing, it means the optimal compensation contract under debt financing is also riskier. Therefore, even if there is no investment inefficiency, it is in general more costly to provide incentives under debt financing than under equity financing.

In some cases, the risk premium required under debt financing is so high that underinvestment in human capital will occur. If underinvestment in human capital will greatly decrease the firm's profitability, human capital underinvestment might lead to capital underinvestment.

In a risk-neutral world, debt financing also has disadvantage in providing incentives to tech workers. When debt level is high enough, the shareholder will want to discontinue the project suboptimally in some states of the world. That leaves the shareholder fewer states to compensate the tech workers. If the cash flow net debt payment in the good states are not enough to compensate tech workers in expected terms, then underinvestment in human capital will occur. It is therefore optimal to have low debt in human capital intensive firms.

This paper also models an entrepreneur who makes business decisions such as capital structure and continuation. I interpret her as the founder of a startup firm, or a top manager in a mature firm. Other than making business decisions, the entrepreneur differs from the tech worker in that her investment in specific human capital could be taken as given. It is reasonable to think that a founder of the firm specializes herself to the firm before she starts the firm. And a manager has made her specific investment during the process of studying a project and making the decision on whether or not to take it. The entrepreneur, however, also needs exert effort to increase the firm value. In the base case of the model, I assume her human capital supply is not subjected to incentive problems because of non pecuniary reasons. I then relax this assumption and study how her incentive is affected by capital structure. Debt financing, while causing difficulty in incentivizing the tech worker, encourages the entrepreneur to work harder.

I also show that granting stock options to managers can have different incentive implications in a human-capital intensive firm, compared to in a traditional firm . Options are cheaper than unlevered equity. It is therefore feasible to let the managers hold more options than equity and to better align their incentives. On the other hand, stock options raise the bar over which the managers will continue the project and therefore cause negative incentive impact on the tech workers. Granting options to the tech workers, on the other hand, has only positive effects.

I empirically test the prediction of my theory model, that is, human-capital intensive firms tend to borrow less. Proxies for human-capital intensity are constructed for the test. These proxies balance between the relative importance of labor to capital and the importance of human capital to low skill labor. Controlling for a fairly comprehensive list of traditional capital structure determinants, I find a negative relationship between financial leverage and human-capital intensity. In particular, human-capital intensity has explanatory power in addition to the collateral value of firm assets and the firm's growth opportunity. This negative relationship is statistically significant as well as economically significant. It is also robust to different regression methods and econometric specifications.

Another implication of the model is that incentive problems will be more severe, the more specific human capital the employee needs to develop. Therefore I also test the hypothesis that the more specific the firm's assets are, the stronger is the negative relationship between the financial leverage and human-capital intensity. Two measures of firm specificity are used: R&D and Parrino's (1997) measure for industry homogeneity. I find the relationship between leverage and human-capital intensity depends on these measures, in the way predicted by my theory.

The paper is organized as follows. In the next section, I discuss the related literature and my paper's position in the literature. I describe the model in section 3 and present the results in section 4. In section 5, I consider the entrepreneur's incentive problem. I demonstrate the trade-off between the debt and equity financing in incentivizing the entrepreneur and the tech worker. I also discuss the incentive implications of stock options. The capital structure hypothesis is tested in section 6.

2 Literature review

This paper is motivated by the new emphasis on human capital in studying corporate finance, advocated by some finance researchers. Zingales (2000) proposes that as the nature of the firms changes from being physical-asset intensive to human-capital intensive, the field of corporate finance has to adjust itself to understanding how corporate decisions might change the boundaries of the firms. Rajan and Zingales (2000) make a case that the focus of the corporate governance must shift form strengthening the rights of owners to controlling and retaining human capital. Rajan and Zingales (2001) again argue that due to technology advance and financial innovations, the power balance has shifted to human capital providers from financial capital providers. This change has profound implications on the theory of the firm. Myers (1999) also stresses the significance of human capital in determining corporate decisions. He states, "financial architecture adapts to support the co-investment of human and financial capital." By financial architecture, he means "the entire financial design of the business, including ownership (e.g. concentrated or dispersed), the legal form of organization (e.g. corporation vs. limited-life partnership), incentive, financing and allocation of risk."

This paper describes a hold-up problem related to the employee's specific human capital investment. The value of the specific investment is significantly lower or close to zero if not employed in the same firm. Therefore the employer of the firm can hold up the employee ex post. This type of relation-specific investment problem is not new. It is at the heart of the literature of the boundaries of the firm. Until very recently, two strains of work have dominated the research of the boundaries of the firm: transaction cost economics and property rights theory. Holmstrom and Roberts (1998) give a nice survey on both. They state, "Both theories, while quite different in their empirical implications, focus on the role of ownership in supporting relationship-specific investments in a world of incomplete contracting and potential hold-ups."

The two theories, of course, have more distinctions than just their empirical implications. But for the purpose of providing a context for this paper, I would like to emphasize their common thinking: the use of ownership to mitigate hold-up problems and enhance efficiency. The problem under question arises if one party need make relation-specific investment, when two parties, i.e., the owners of two pieces of distinctive assets, transact with each other. If it is infeasible or too costly to write contingent contracts, the party that makes the investment is possibly held up ex post. That party is at a disadvantage in the transaction because the product of its specific investment is worth considerably less if it does not transact with the other party. Such ex post vulnerabilities calls for some ex ante device to improve ex post bargaining power. One powerful device is ownership.

Modern transaction cost economics represented by Williamson (1975, 1985), Klein, Crawford and Alchian (1978) argue that such problems are reasons for internal coordination instead of market transaction. If specific investment is incurred under common ownership, there is no hold-up problem. The more frequent, the more uncertain the transactions are and the more specific the assets involved, the more likely the internal governance will be adopted.

The property rights theory, pioneered by Grossman and Hart (1986), takes ownership of non-human assets as the defining characteristic of firms: a firm is exactly a set of assets under common ownership. The modern transaction cost theory implicitly assumes that integration yields the same outcome that would arise under complete contracts and therefore is always (weakly) better than nonintegration. Grossman and Hart (1986) allow for investment on the part of both parties and conclude that integration shifts the incentives for opportunistic behavior, but does not remove them. Ownership, i.e., the residual rights of control, improves a firm's status quo in the ex post bargaining. It therefore improves its distribution of ex post surplus, and hence affects ex ante investment decisions. Ownership should lie with the party that makes most important investment. In cases where both parties of investments are important, non-integration might be good.

Hart and Moore (1990) further clarifies the role of ownership in mitigating underinvestment problem and improving efficiency. An agent is more likely to own an asset if she makes important investment or if she is a crucial trading partner (thus is indispensable). In addition, common ownership of two assets by agent 1 (instead of being owned by agents 1 and 2, separately) is likely to increase efficiency if (1) the assets are strongly complementary; (2) 1 is an important trading partner for 2 and the workers of 2; and 2 is dispensable; (3) 1 or the workers of 1 have important investments.

The caveat in both theories when they use ownership to solve the investment problem is that they do not quite apply to human capital. Underinvestment in human capital arises because employees need to make firm-specific human capital investments. Carrying out the solution proposed by these theories, the owner of the firm should own the human capital as well to solve the hold-up problems. However, human capital cannot be separated from the person and slave labor is not allowed. Inalienability of human capital and effective constraints on involuntary servitude makes the human capital problem a very distinctive one. It is generally infeasible for the tech worker (as a simplification, assume they are a unified group) to own the whole firm due to the simple reality that they are wealth-constrained. If firm-specific human capital investment and its costs are observable, it is efficient for the firm to pay for the optimal level of investment. But a great deal of such investment is unobservable and private to the individual employee. Hence the underinvestment problem in human capital is not solvable by ownership. I thus propose a partial solution through capital structure.

Rajan and Zingales recently extended the theories of firms in a series of papers such as Rajan and Zingales (1998, 2000, 2001). The critical resource theory of firms, as it is called, broadens the view of boundaries of a firm. In modern firms, they contend, ownership of non-human assets are not always a bargaining tool as powerful as accessibility to critical resources. Control over the critical resources is a source of power and can provide better incentives than ownership. The organization, the realm of transactions governed by authority rather than by prices, consists of its critical resource and the agents and other critical resources that are tied to it via complementarity.

The critical resource theory describes the power from access as follows in Rajan and Zingales (1998) "The agent who is given privileged access to the resource gets no new residual rights of control. All she gets is the opportunity to specialize her human capital to the resource and make herself valuable." While describing how an agent could make herself valuable by developing specific human capital, it does not explore the question how she is ensured that she will have continued access to the critical resource after she develops her specific human capital, which is exactly the problem discussed in this paper.

There are other papers that address the hold-up problems due to relation-specific investments. Titman (1984) considers the implicit costs that liquidation will cause to a firm's customers and other associates that have made relation-specific investment in the firm. A value-maximizing firm will commit itself to liquidate only in those states where the liquidation value exceeds the continuation value by an amount greater than the costs imposed on its customers. An optimal capital structure will do the job. Under simplifying conditions, the theory implies that *ceteris paribus*, firms that impose potentially large costs on their customers in event of liquidation, choose low levels of debt which lead to bankruptcy only in few states of nature. However, the time-inconsistency problem of optimal liquidation described in his paper is not solved by pure equity. The optimal capital structure is a delicate balance between debt, preferred equity and common equity. Despite the prediction of a negative relation between the debt and the potential liquidation costs, such relation is not predicted between the sum of debt and preferred equity, and the potential liquidation costs. Titman and Wessels (1988) test the hypothesis that firms with more specific assets have higher liquidation costs, therefore lower leverage. They use R&D expenses and SGA (selling, general and administration) expenses as proxies for asset uniqueness and a negative relation between leverage and asset uniqueness.

Shleifer and Summers (1988) argue that part of the equity value increase associated with takeover might be a transfer of wealth from stakeholders of firms to equityholders, rather than creation of wealth. There are implicit contracts between old management and stakeholders who have made specific investment following the implicit contract. Transfer of wealth occurs after takeover because these implicit contracts are not to be honored.

Berkovitch, Israel and Zender (1997) propose a bankruptcy procedure that biases the bargaining power toward the entrepreneur against the creditors. It thus gives ex ante incentive to the entrepreneur to invest in the firm-specific human capital.

Jaggia and Thakor (1994) also present the firm-specific human capital investment problem. A firm trades off the advantage of the long-term contract which encourages workers to invest, and the disadvantage it brings that the firm cannot fire them if they turn out to be the bad type. If the former consideration is more important, the firm will use long-term contract. Since bankruptcy will terminate the commitment, more specific firms should take less leverage.

These papers address relation-specific investment and propose different mechanisms to encourage such investments. The solutions suggested by Titman (1984) and Jaggia and Thakor (1994) involve capital structure. This paper is similar in these respects. However, this paper differs in important ways: First, it is not a bankruptcy story. The friction involved is the distorted continuation incentive on the shareholders' part in presence of debt and therefore changes the bargaining game. In equilibrium, there might not be inefficient capital investment or human capital investment, but debt will lead to inferior risk sharing between the shareholders and the employees. Therefore, the shareholders have to pay high risk premium and receive less expected payoff. Other than capital structure, this paper also studies other aspects of human-capital intensive firms, such as top management compensation and renegotiation form design. These features are not in the above papers.

The idea that the shareholders can use debt as a bargaining tool against workers is discussed by Perroti and Spier (1993). However, they focus on ex post capital structure maneuvering, while I am interested in the ex ante optimal capital structure.

In terms of empirical hypotheses, the predictions on capital structure and stock options to top management are new. So are the testing. This paper therefore adds to the literature of capital structure. In theory, it identifies another factor that determines the capital structure. Empirically, it finds supporting evidence on the negative relationship between leverage and human-capital intensity. Harris and Raviv (1991) provide a nice survey on both theoretical and empirical works on capital structure. Two types of theories compete to explain firms' capital structure choice: the trade-off theory and the pecking order theory . The trade-off theory believes that firms balance the advantages and disadvantages of debt and adjust to the optimal target leverage level. The pecking order theory, represented by Myers and Manjluf (1984) and Myers (1984), predicts no optimal target leverage level. Instead, due to the lemon costs associated with asymmetric information, firms will use internal funds first, then debt and finally equity. Empirical findings suggest there are some truth in both theories. For example, see Brealey Fama and French (2001). It is unlikely that the pecking-order theory is true in its strict sense because firms do have other concerns related to debt. This paper fits into the trade-off theory regime of capital structure because it identifies one determinant of capital structure, among others. More empirical papers will be discussed in section 6.

3 The Model

There are three parties that play in the game: an entrepreneur who controls the access to the project, an investor who provides financial capital and a tech worker who will supply her human capital. In the base case of the model, I do not consider the role of the entrepreneur's human capital. The entrepreneur is a dummy for the existing shareholder and always tries to maximize the existing shareholder's wealth. Both the entrepreneur (the existing shareholder) and the new financial investor are risk neutral while the tech worker is risk averse.

It is often assumed in entrepreneurial economics literature that the entrepreneur is the same person who provides human capital. This may be true or not. I separate these two roles for several reasons. First of all, the subject of this paper is human-capital intensive firms, which differ from traditional managerial firms in that it has broad-based human capital. In these firms, the human capital of non founder tech workers is collectively more important than that of the founder(s). Secondly, the entrepreneur or the founder, may differ from the typical human capital supplier in that her firm-specific human capital investment is realized before she seeks financing. That difference has important implications in terms of financing decisions, as I will demonstrate later. Thirdly, although the entrepreneur's effort and creativity are very important to firm value, it is reasonable to assume that she does not have incentive problem because of non pecuniary reasons such as egos and reputation concerns. If that is the case, financing decisions will hardly affect her human capital decisions. It is the tech workers' human capital inputs that depend on the compensation structure, which is influenced by financing decisions. Finally, by separating the role of the entrepreneur and the tech worker, I can disentangle the incentives of a shareholder and a human capital supplier. Although employees are often granted the company's stocks/stock options, to the extent that their main incomes are still from non-equity sources, their interests are different from large shareholders. I later relax the assumption that the tech worker does not hold shares and my main results hold. I also study the situation in which the entrepreneur's human capital supply is also subject to incentive problems. I point out the trade-off of debt financing and equity financing under such a situation. But for now, I assume that only the tech worker supplies human capital and the entrepreneur is always perfectly aligned with existing shareholders' interests.

There are two periods and three dates in the model: date 0, 1 and 2. On date 0, the entrepreneur has access to a project and seeks to finance the required capital investment I. Without loss of generality, I assume that the entrepreneur has no wealth of her own and that she needs to raise the whole amount of required capital I from the investor. To simplify the model and to highlight the contrast between debt and equity financing, it is assumed the firm is financed either by debt or by equity. This is not a crucial assumption. It can be shown that the main result holds under a mixed capital structure. [1] If the project is financed with debt, the investor holds a debt claim with face value D and the entrepreneur is the sole shareholder. The debt is risky, that is, the firm's cash flow under some states of nature cannot pay off the face value of the debt. If the project is financed by equity, the investor is promised $(1-\alpha)$ share of the firm and the entrepreneur holds α share of the firm.

The entrepreneur then hires a tech worker who will provide human capital in the production process and the two parties sign a compensation contract. I denote the contract as Ψ and the compensation vector stipulated in the contract as W. The tech worker has a utility function $U = U(W)$, where $U(\cdot)$ is an increasing and concave function.

The entrepreneur makes the capital structure choice to maximize her expected payoff on this project. Given that all the financial securities are correctly priced, it is equivalent that the entrepreneur maximizes the firm value net the expected compensation to the tech worker. Observing the entrepreneur's move, the tech worker makes her decision on firm-specific human capital investment in the first period, denoted as H. The human capital investment is private to the tech worker and cannot be observed by other parties. For simplicity, I assume this is a binary choice: $H = 0$,or 1. $H = 0$ means that the tech worker makes low human capital investment and $H = 1$ implies high human capital investment. It is assumed that if $H = 0$, there is no cost to the tech worker. The tech worker invests $H = 1$ at a dollar cost of C, which incurs a utility cost of $V(C)$. The cost function not only reflects the foregone leisure and consumption of energy that need to be compensated, it also includes the opportunity costs of specializing one's own human capital.

It is common knowledge that the final payoff of the project at the end of the second period, X, depends on both the state of nature realized then, θ, and the tech worker's investment of firm-

[1] I later discuss the possible usage of more sophisticated securities such as convertible debt.

specific human capital during the first period, H. I assume $X = \theta + f(H)$, where f is increasing in H. There are three possible states of world: low state, medium state and high state, (denoted as θ_L, θ_m, θ_h), with probability p, q and $(1 - p - q)$, respectively.

At the end of the first period, the firm receives a perfect signal on the state of nature. The signal is observed by all parties involved. However, the signal is not verifiable. Therefore, contracts cannot be written on this information. The entrepreneur will then make a continuation decision on behalf of shareholders' interests. If the project is not to be continued, it will yield a state-independent liquidation value L. Since the debt is risky, $L < I < D$.

If the entrepreneur decides to continue the project, the tech worker applies her human capital during the second period and the final cash flow $X = \theta + f(H)$ is realized on date 2. If the project is liquidated on date 1, the final cash flow is L. The final payoff X is observable and verifiable once it is realized, the two parties can write enforceable contracts over X and the contract can be enforced once X is realized. Wages will be paid first.[2] Then debt is paid off, if there is any. The shareholders (the entrepreneur and the new financial investor in case of equity financing) keep the residual cash flow. The shareholders have limited liability.

Although the entrepreneur (on behalf of all shareholders) signs a contract with the tech worker on date 0, the non verifiability of the state of nature renders the contract incomplete. That is, the contract cannot specify the continuation decision and compensation conditional on θ. This incompleteness in the contract might lead to an ex post hold-up problem between the shareholder and the tech worker on date 1. On the interim date, the tech worker has sunk her investment in human capital. If she is denied the opportunity of continuing to work on the project, her investment in the specific human capital has little value elsewhere. The entrepreneur could, and has the incentive to hold up the worker by threatening not to continue the project unless the worker takes a compensation cut.[3]

In a rational expectation world, both parties take this potential ex post bargaining game into

[2] In this simple model, the compensation contract could be written in the form of output(X)-contingent wages. Wages have priority over debt. Later I will discuss the case where compensation is comprised of fixed salary and equity.

[3] I preclude the possibility in the model that the shareholders will renegotiate with the debtholders. However, it is not a crucial assumption. A trilateral bargaining might change the magnitude of the problem but will not eliminate the problem.

account. An efficient contract will therefore be designed in such a way that it is not subject to renegotiation. In this model, renegotiation is of no value. If there are any bargaining costs involved, then it is better to design a renegotiation-proof contract. For this reason, the set of contracts under consideration is restricted to renegotiation-proof contracts.

The renegotiation-proof compensation level depends on the ex post bargaining results if bargaining occurs. The ex post bargaining results in turn depend on the bargaining power distribution on date 1. Corresponding to each distribution of ex post bargaining power, there will be a optimal renegotiation-proof compensation vector. As will be demonstrated later, the ex ante contract can determine the ex post bargaining power by designing the bargaining procedures. Therefore the contract will consist of two arguments: the bargaining power assignment and the compensation vector accordingly, i.e., $\Psi = \Psi(W, \varsigma)$, where ς is the bargaining power distribution. $\varsigma = (\phi, 1-\phi)$, where ϕ is the shareholders' bargaining power. It is possible there are legal or feasibility restrictions so that ex post bargaining power distribution can not be determined in the contract. In the appendix, I analyze the model assuming an exogenous ex post bargaining game. The main results hold.

The timing of events are summarized in figure 1.

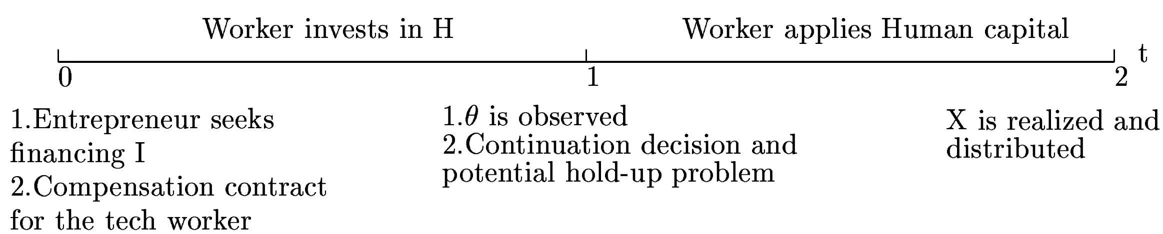

Figure 1: Time line of events

4 The Analysis

4.1 The First best

I make the following assumptions to facilitate the analysis:

Assumption 1

$$\theta_L + f(1) < L$$
$$\theta_m + f(0) > L$$
$$\theta_h > L$$

Assumption 2

$$p[\theta_h + f(1)] + q[\theta_m + f(1)] + (1 - p - q) * L > I$$
$$p[\theta_h + f(1)] + q[\theta_m + f(1)] + (1 - p - q) * (\theta_l + f(1)) < I$$
$$p[\theta_h + f(0)] + q[\theta_m + f(0)] + (1 - p - q) * L < I$$

Assumption 3 $(p + q)(f(1) - f(0)) > C$

Assumption 1 shows the project's profitability under each state of nature. It says that the continuation value of the project is greater than the liquidation value in both medium and high states, but lower than the liquidation value in the low state even with high human capital investment. Assumption 2 shows the profitability under different investment decisions. The first inequality says that with human capital investment and liquidation in low state, the project has a positive NPV. The second inequality shows that the low state is so bad that unconditional continuation is not optimal. The third condition demonstrates the importance of the human capital investment. Without human capital investment, the project has negative NPV. This assumption is testimony that the subject of our study is firms where human capital investment is very important. Assumption 3 assures that it is efficient to invest in the specific human capital.

The first best is achieved if the business decision maker (in my model, the entrepreneur), the financial capital supplier and human capital supplier are all perfectly aligned, or if contracting could be complete. Suppose a social planner makes decision for all three parties in such a case. Given assumption 1, the planner will continue the project if and only if $\theta \geq \theta_m$. With assumption 3, it is optimal for her to invest in the firm-specific human capital, i.e., $H = 1$.

Since the new security, be it equity or debt, is correctly priced, the new financial investor will earn zero NPV on the project and will get paid back I on expected terms. The rest of the firm value will be divided between the entrepreneur (the old shareholder) and the human capital supplier. A compensation contract could be written on all the information available in the first best, hence $W = W(\theta, H, \gamma)$, where $\gamma = 1$ if the project is continued and $\gamma = 0$ otherwise. Note that the final cash flow X is determined once θ, H, γ are fixed.

An efficient compensation contract should solve the following problem:

$$\min_{W} \; EW(\theta, H = 1, \gamma)$$

$$\text{st.} EU(W(H = 1)) - V(C) \geq \underline{U}$$

where EW is the expected compensation level, EU is the expected utility from earning the wage vector W, $V(C)$ is the utility cost of high human capital investment and $\underline{U}$ is the tech worker's reservation utility. The level of reservation utility reflects the tech worker's outside options and her bargaining power ex ante in splitting the firm value with the shareholder.

It is easy to show that the efficient compensation contract is a fixed salary which is state-independent and γ-independent. The intuition is clear. Since $H = 1$ can be implemented unconditionally in the first best, there is no need to make the risk-averse tech worker bear any risk. It is best to provide her with perfect insurance against all the possible states of nature. Therefore, the solution to the above problem is $W = W^0 = U^{-1}(V(C) + \underline{U})$. Since contracting is complete in the first best, ex post bargaining is not allowed to happen. The ex post bargaining power does not affect the equilibrium. In other words, the contract need only specify W.

The first best decision rules are as summarized as follows: (1) to make human capital investment i.e., $H = 1$; (2)to continue the project in both medium and high states, i.e., $\gamma = 1$ iff $\theta \geq \theta_m$; (3) the tech worker is paid a fixed salary, i.e., $W = W^0 = U^{-1}(V(C))$. Under these decision rules, the firm value is:

$$V_0 = p[\theta_h + f(1)] + q[\theta_m + f(1)] + (1 - p - q)L$$

The expected payoff to the shareholder is:

$$\pi_0 = p[\theta_h + f(1)] + q[\theta_m + f(1)] + (1 - p - q)L - I - W^0$$

Assuming $U = V$ and $\underline{U} = 0$, then

$$\pi_0 = p[\theta_h + f(1)] + q[\theta_m + f(1)] + (1 - p - q)L - I - C$$

4.2 Hold-up problem and renegotiation-proof contracts

The first best can be achieved if a complete contract between the shareholder and the tech worker could be written. In particular, the first best can be achieved if the following could be specified in the contract: (1) the continuation decision conditional on the observed state of nature and (2) the compensation conditional on the tech worker's human capital investment. However, either θ and H is not contractible.

Since the investment in human capital is private to the tech worker and not observable to the others, the shareholders need to link her compensation to the project's output to encourage her to make the investment. The final cash flow of the project is the only variable in the model that is both observable and verifiable. The final cash flow X is equal to $\theta + f(H)$ if the project is continued and is equal to L if it is liquidated on date 1. Unlike in the first best, the compensation W can only be a function of X, hence $W = W(X)$. The worker also has limited liability, i.e., $W(X) \geq 0$.[4] It is implied that if the project is liquidated prematurely, then $W = W(L)$, independent of θ and H. In the three-state model, if the project is carried out to date 2, the H investment could be deduced from the cash flow. However, if the project is liquidated on date 1, the tech worker loses the opportunity to apply her human capital and proves that she has invested in specific human capital. The firm does not want to pay too much when they liquidate the project because the state and H-independent liquidation value does not help reveal the tech worker's human capital investment. Paying too much in non-discriminating states will discourage the tech worker not to invest.

[4]If negative compensation is allowed, the incentive problem could be trivially solved by imposing severe punishment whenever the final cash flow is such that it can be inferred $H = 0$.

The tech worker's compensation depends on the continuation decision. But it is not possible to stipulate in the contract the right continuation decision conditional on θ since θ is non verifiable. Neither is unconditional continuation optimal. Therefore the shareholders may want to take advantage of the incompleteness of the contract and renegotiate the compensation contract on the interim date using the continuation decision as a bargaining tool.

In the event of hold-up, the entrepreneur will express intention to renegotiate. Then they renegotiate following the procedures specified in the contract.

The cash flow the shareholders are entitled to, if the project is carried through to date 2, is $(\theta + f(H) - W(X) - D)^+$. The cash flow the shareholders can receive under liquidation is, $(L - W(L) - D)^+$. Given the second condition in assumption 2, the entrepreneur will never want to continue the project in the low state. The compensation in the low state will be W(L).

The hold-up problem might arise in the medium and high states. With Assumption 1, $\theta_m + f(1) > L$. Under equity financing, the entrepreneur and the tech worker can be both made better off by continuing the project as long as the $W(L)$ is not too high. As will be shown later, $W(L)$ should be set to zero in the optimal contract. Therefore in equilibrium, the entrepreneur will continue the project under equity financing and the tech worker will make enough concession when necessary. In this section, I also assume that $\theta_m + f(1) > D$. As a result, the entrepreneur will also continue under debt financing, if the tech worker makes enough concession.

With this additional assumption, there is no distortion in the continuation decision. The optimal compensation contract will make sure that $H = 1$ is taken. Otherwise it makes no sense to take the project. Therefore in equilibrium, there is no distortion in both capital investment and human capital investment decisions, hence the firm value will be equal to V_0.

However, the optimal compensation will differ under the equity financing and debt financing and I argue that the optimal compensation under equity financing will lead to better risk sharing between the shareholders and the tech worker. The difference comes from the different bargaining results under different capital structure if renegotiation occurs.

I first calculate what the tech worker can bargain for herself under a fixed bargaining power distribution, if renegotiation occurs. For the ex ante contract to be renegotiation-proof, the compensation level has to be equal to or less than what she can bargain for herself. I call this constraint on the compensation vector the renegotiation-proof constraint.

Figure 2a presents the payoffs for the shareholders and the tech worker when the entrepreneur initiates the renegotiation talks. The first column displays the payoffs if the project is continued. The second column shows the payoffs if the project is liquidated. The total payoff to both of them if the project is continued is $\theta + f(1)$, while the total payoff if the project is liquidated is L, where $\theta = \theta_m$ or θ_h. The total surplus of the successful bargaining is $\theta + f(1) - L$. Given bargaining power distribution $(\phi, 1-\phi)$, the tech worker can bargain for herself $W(L)+(1-\phi)*(\theta+f(1)-L)$. For the contract to be renegotiation-proof, the compensation function has to satisfy $W(\theta+f(1)) \leq W(L) + (1 - \phi) * (\theta + f(1) - L)$. It is also clear that $W(\cdot)$ is a (weakly) increasing function so that right incentive can be provided. Therefore the renegotiation-proof under the equity financing is $W(L) \leq W(\theta + f(1)) \leq W(L) + (1 - \phi) * (\theta + f(1) - L)$.

The optimal renegotiation-proof compensation contract under equity financing solves the following problem, if it specifies $\varsigma = (\phi, 1 - \phi)$:

$$\begin{aligned}
& \min_W \ EW(X) \\
\text{st.} \quad & EU(W)|_{H=1} - V(C) \geq \underline{U} && \text{(IR)} \\
& EU(W)|_{H=1} - V(C) \geq EU(W)|_{H=0} && \text{(IC)} \\
& W(L) \leq W(\theta + f(1)) \leq W(L) + \phi(\theta + f(1) - L) && \text{(RPE)} \\
& W(X) \geq 0
\end{aligned}$$

The first constraint is the individual rationality constraint, which says in equilibrium the tech worker's expected utility is no less than her reservation utility. The incentive compatibility (IC) constraint assures that the tech worker will make high human capital investment since her expected utility if she makes high investment is larger than or equal to her utility if she makes low investment. The third constraint is the renegotiation-proof constraint, as explained above. The last one is the non negativity constraint or limited liability constraint.

It is proved in the appendix that $W(L)$ should be set to zero. Therefore the problem can be rewritten as (denoted as problem (E))

$$\begin{aligned}
&\min_W \; EW(X) \\
\text{st.} \quad & EU(W)|_{H=1} - V(C) \geq \underline{U} && \text{(IR)} \\
& EU(W)|_{H=1} - V(C) \geq EU(W)|_{H=0} && \text{(IC)} \\
& W(\theta + f(1)) \leq \phi(\theta + f(1) - L) && \text{(RPE)} \\
& W(X) \geq 0 \\
& W(L) = 0
\end{aligned}$$

The optimal compensation contract under debt financing will be subjected to the same (IR) and (IC) conditions. However, the renegotiation-proof condition will be different. Figure 2b presents the payoffs for the shareholders and the tech worker under debt financing when the entrepreneur initiates the renegotiation talk. The total payoff to both of them if the project is continued is $\theta + f(1) - D$. The total payoff if the project is liquidated is $W(L)$, since the wage has priority over the debt. The total surplus of the successful bargaining is $\theta + f(1) - D - W(L)$. Given bargaining power distribution $(\phi, 1-\phi)$, the tech worker can bargain for herself $W(L) + (1-\phi) * (\theta + f(1) - D - W(L))$. For the contract to be renegotiation-proof, the compensation function has to satisfy $W(L) \leq W(\theta + f(1)) \leq (1-\phi)W(L) + (1-\phi) * (\theta + f(1) - D)$. As proved in appendix, $W(L) = 0$. Therefore the optimal renegotiation-proof compensation contract under debt financing solves the following problem, if it specifies $\varsigma = (\phi, 1-\phi)$: (denoted as problem (D))

$$\begin{aligned}
&\min_W \; EW(X) \\
\text{st.} \quad & EU(W)|_{H=1} - V(C) \geq \underline{U} && && \text{(IR)} \\
& EU(W)|_{H=1} - V(C) \geq EU(W)|_{H=0} && && \text{(IC)} \\
& W(\theta + f(1)) \leq \phi(\theta + f(1) - D) && \theta = \theta_m, \theta_h && \text{(RPD)} \\
& W(X) \geq 0 \\
& W(L) = 0
\end{aligned}$$

I denote the optimal compensation vector W under equity financing as $W_E^*(\phi)$, the optimal compensation under debt financing $W_D^*(\phi)$. They are the solution to the problem (E)and problem

(D), respectively. Note these two problems are the same except for (RPE) and (RPD). Since $L < D$, it is evident that the renegotiation-proof constraint under debt financing is more stringent than the renegotiation-proof constraint under equity financing, given each bargaining power distribution. Therefore the optimal solution under equity financing is always (weakly) better than that under debt financing.

Proposition 1 (Optimality of equity financing) *Given any bargaining power distribution, the expected compensation to the tech worker is less under equity financing than under debt financing, i.e.* $EW_E^*(\phi) < EW_D^*(\phi)$.

Proposition 1 tells that equity financing makes possible better risk sharing between the shareholders and the tech worker. Ideally, the risk-averse tech worker should not bear any risk. Perfect insurance is not feasible here since the human capital investment cannot be monitored and can only be encouraged by linking pay to output. That is the theme of the standard principal-agent theory. The contribution of this paper is to point out that the contracting problem is subject to one more dimension of incompleteness, that is, the continuation decision is at the shareholders' discretion and is not contractible. To reduce the shareholders' incentive to hold up the tech worker, the compensation level in some states have to be kept low to give the shareholders incentive to continue the project. To compensate low wages in some states, the wages in good states have to be higher. The tighter the constraint on the wages in the states where hold-up problem might arise, the riskier the compensation structure will be. Debt financing therefore leads to riskier compensation structure High risk premium is required under debt financing. Debt causes social inefficiency because of bad risk-sharing. It also results in lower expected payoff to the shareholders.

My model concludes that equity financing is optimal for a human-capital intensive firm. Of course, the author recognizes that debt has its own advantages in increasing the firm value. For example, it provides tax shield; it can also discipline stealing managers, etc. These advantages are not modeled in the paper because they are not new insights. This paper points out one particular disadvantage of debt, i.e., it causes difficulty in incentivizing human capital investment. The paper argues that this problem is severe where human-capital investment is important. The optimal capital structure trades off the goodness and badness of debt and my model implies that human-capital intensive firms should use less debt, *ceteris paribus.*

Another result I obtain by examining both problem (E) and (D) is that the optimality is less constrained the less ϕ is, under any capital structure. That is, it is in the shareholders' ex ante interest to give the tech worker full bargaining power if renegotiation occurs. One way to commit to $\phi = 0$ is to specify that if the entrepreneur initiates renegotiation, the tech worker will make a take-it-or-leave-it offer. The entrepreneur will either take the offer and the new contract will be enforced, or, the renegotiation breaks down and the entrepreneur will make continuation decision rationally and the initial contract will be enforced according to the final output. I hence obtain the following proposition.

Proposition 2 (Optimality bargaining power distribution) *Under any capital structure, the shareholders' expected payoff is higher if the contract specifies a renegotiation form that corresponds to* $\varsigma = (0, 1)$. *One way to do that is to specify that in event of renegotiation, the tech worker gets to make a take-it-or-leave-it offer.*

Giving full bargaining power to the tech worker is again to make the renegotiation-proof constraint less tight so that the compensation structure can be as smooth as possible. Better risk sharing could be achieved by granting a less risky compensation to the tech worker. S smoother compensation structure also means less risk premium required and higher expected payoffs to the shareholders.

It is shown in the proof for proposition 1 that $W(\theta_m + f(0)) = 0$ and $W(\theta_m + f(1)) = 0$ since they are both on the off-equilibrium path. Therefore only $W(\theta_m + f(1))$ and $W(\theta_h + f(1))$ could be positive in equilibrium. I denote them as W^h and W^m, respectively. Figure 3 helps to demonstrate the intuition of the above two propositions. The convex curve in the W^h-W^m diagram is the tech worker's indifference curve, say at the reservation utility level. Each parallel straight line with negative slope represents a certain expected compensation level. That is, each line represents the function of $p * W_h + q * W_m = EW$, where EW is the constant expected compensation level. The expected compensation level increases when the line moves toward the north-east direction. Without any restriction on the compensation levels in both states, the point that has the lowest expected compensation on the tech worker's indifference curve is its intersecting point with the 45^o

line. This means that the smoothest compensation structure requests the lowest risk premium. As the expected compensation increases, the expected payoff to the shareholders decreases. The line with expected compensation level of $\overline{EW}$ represents the highest risk premium the shareholders can afford. The project will have negative NPV to the shareholders if the tech worker is paid at a higher level. As described in the model, the potential hold-up problem between the shareholders and the tech worker might put a upper limit on the compensation levels. Suppose only the constraint on W^m is binding and the constraint is that $W^m \leq W_1$. That is, only the region left of the vertical line $W^m = W_1$ is feasible. As shown in the graph, the tech worker has to be paid more than $\underline{\text{EW}}$. As the vertical line moves to the left, the more distant the solution is from the 45^o line the higher expected compensation the tech worker will be paid. This means the more stringent the constraint is, the riskier the compensation structure and the higher risk premium the shareholders have to pay. At some point, e.g., if $W^m \leq W_2$, the risk premium required is too high that the shareholders will give up the project. This scenario will be demonstrated by the numerical example below.

Figure 4 displays the relationship between the expected payoff to the shareholders and the debt value. The two curves in the graph represent two projects respectively. I assume the projects are such that there will be no capital underinvestment so that the face value of the debt will be at most $\bar{D} = \frac{I-(1-p-q)L}{p+q}$. For both projects, the shareholders' payoff (weakly) decreases with the debt level, because they have to pay higher and higher expected compensation to the tech worker. During the range when the debt is riskfree, i.e., when $D < L$, the feasible set of the renegotiation-proof contracts is the same as under pure equity. When $D > L$, the feasible set in general decreases with D. The risk-premium required by the tech worker is higher and the expected payoff to the shareholders is lower. For the curve on the right, the project still pays something to the shareholder even if it takes pure debt financing. The other project is such that even if there is no distortion in the continuation decision, the risk premium associated with high level of debt is so high that the project will yield zero payoff to the shareholder and therefore they will not take the project in the first place.

The main principle and the scenarios discussed above may be better clarified by the following the numerical example.

4.3 Two numerical examples

Suppose the project needs investment of $I = 100$. Its liquidation value will be $L = 50$ on date 1. The tech worker has a utility function of $U(W) = 300W - W^2$ and a zero reservation utility. The cost of high human capital investment is $C = 20$. Assuming $V = U$. the utility cost of making the investment is $V(20) = 5600$. $\theta_h = 200$, $\theta_m = 80$ and $\theta = 0$, with probability of 0.2, 0.6 and 0.2, respectively. The human capital value is $f(1) = 50$ and $f(0) = 0$. Given that the tech worker makes the high human capital investment, the final cash flow if the project is continued is 250, 130, 50 in high, medium and low state, respectively. If the tech worker does not make high human capital investment, then the continuation value of the project is 200, 80 and 0 respectively.

Under the first best, the project will be continued in both medium and high states and the tech worker will make $H = 1$ since $0.8 * 50 > 20$. Then the NPV of the project is 18. If $H = 0$, even if the continuation decision is not distorted, the project has a NPV of (-2) and therefore is not worth taking.

Under equity financing, the optimal compensation contract will specify that $W = 0$ if $X = 200$, 80, 0 or 50. That is, $W = 0$ if it can be inferred that $H = 0$ or the project is liquidated. The optimal W^* solves the following problem: $\min_W 0.2W(250) + 0.6W(130)$, st. $0.2U(W(250)) + 0.6U(W(130)) \geq 5600$ and $W(130) \leq 130 - 50 = 80$. The solution is that $W(250) = W(130) = 25.5$. That is, the renegotiation-proof constraint is not binding under equity financing. The expected compensation is 20.4 and the risk premium (which is inevitable in the second best) is 0.4.

Under debt financing, debt could be paid back in both medium and high states. Therefore it has a face value of 112.5. The optimal compensation contract will solve the following problem: $\min_W 0.2W(250) + 0.6W(130)$, st. $0.2U(W(250)) + 0.6U(W(130)) \geq 5600$ and $W(130) \leq 130 - 112.5 = 17.5$. The solution is that $W(250)53.4$, $W(130) = 17.5$. The expected compensation is 21.18 and the risk premium is 1.18. In this case, the renegotiation-proof constraint is binding. The compensation level has to be no larger than 17.5. To make it up, the shareholders have to allow for much higher compensation in the high state.

In the above example, the shareholders pay a higher risk premium under debt financing than under equity financing. But in equilibrium, there is no distortion in the continuation decision and no human capital underinvestment. The only inefficiency comes from worse risk-sharing between the parties under debt financing. If I modify the example slightly, it is shown below how failure to incentivize the human capital investment will lead to failure of the whole project.

The only modification I will make to the above example is to make $\theta_m = 68.5$ instead of 80. Under first best, the project has a positive NPV of 11.1. It can be verified that under equity financing, $W(250) = W(118.8) = 25.5$ is still the optimal solution. Under debt financing, the renegotiation-proof condition becomes $W(130) \leq 118.5 - 112.5 = 6$. Even if the shareholders pay all the available cash flow net of debt to the tech worker, it is not adequate to incentivize her. This is because $0.2U(250 - 112.5) + 0.6U(6) < 5600$. Therefore $H = 0$. Given that the human capital investment is not adequate, the project is not profitable and will be abandoned. The tech worker with the quadratic utility function has very reasonable risk aversion. The project has a decent positive NPV (11.1-0.4=9.7 to the shareholders) under equity financing. The debt level is such that by itself, it will not lead to distortion in continuation decision. However, the incentive problem caused by debt financing is so severe that it will lead to underinvestment in human capital, which in turn will lead to capital underinvestment.

4.4 Risk-neutral tech worker

In my base model, I study the case when there is no distortion in the continuation decision and no underinvestment in human capital in the equilibrium. I show that even if the firm value is not affected by capital structure under debt financing, the shareholders receive a lower expected payoff because of bad risk-sharing with the tech worker.

But debt financing can reduce firm value by distorting the shareholders' continuation decision. Myers's (1977) seminal work shows that when the debt level is too high, the shareholders will underinvest in the project because there is nothing left for them. If that is the case, it imposes stronger constraints on the compensation contract the shareholders can promise the tech worker.

Suppose $\theta_m + f(1) < D$. No matter what W^m is, the shareholder will not continue the project in the medium state. This is Myers' underinvestment problem and it will reduce the firm value. This paper points out that Myers' underinvestment may also lead to underinvestment in human capital. Myers' underinvestment may not lead to the demise of the project, but the underinvestment in human capital may in firms where human capital investment is very important.

Given that the project will not be continued in both low and medium states, the shareholders can make the tech worker invest $H = 1$ only if the following is true: $pU(\theta_h + f(1) - D) > V(C)$. If this condition does not hold, the tech worker will not invest in high human capital. In this case, debt financing not only makes the compensation very risky (because positive compensation is only given in the high state), it also reduces the number of states that the shareholders can use to provide incentives.

The last intuition also holds if the tech worker is risk neutral. If the tech worker is risk neutral, the issue of risk-sharing is gone. If there is no distortion in the continuation decision, the firm can always incentivize the worker to make high human capital investment under a profitable project. However, if the debt level is so high that it will lead to underinvestment on the shareholders' part, then it leaves few states available in which the shareholders can make judgements about the tech worker's human capital investment and reward her accordingly. If all the *expected* cash flows in those good states are not enough to compensate her for taking high human capital investment, then underinvestment in human capital will occur. In my model, if $p(\theta_h + f(1) - D) < C$, then underinvestment in human capital occurs.

In this section, I demonstrate the disadvantage of debt in incentivizing the non founder tech worker's human capital investment. Even if debt does not lead to inefficiency in either capital or human capital investment, debt causes inferior risk-sharing between the shareholders and the risk-averse tech worker. This results in a higher risk premium paid to the tech worker and a lower expected payoff to the shareholders. Sometimes the risk premium required is so high that it will lead to underinvestment in human capital, which will in turn lead to capital underinvestment. Finally, I show that if debt level is so high that distortion to the continuation decisions occur, it leaves fewer states to compensate the tech worker and that might lead to underinvestment in human capital as well. This also holds in a risk-neutral world.

5 The entrepreneur's human capital, capital structure and options

The entrepreneur's human capital could also be very important to the firm value. In this section, I relax the assumption that the entrepreneur's human capital is not subject to incentive problems. Thus I cannot take for granted the input of the entrepreneur's human capital, and need to analyze the effects on it of financing decisions.

The entrepreneur's incentive differs from that of the tech worker in the following important way: the entrepreneur's H investment is always equal to 1. The entrepreneur specializes in the project before she seeks financing. As the founder of the firm, she specializes in the process of coming up with the business or product idea. The entrepreneur in the model can also be interpreted as a manager in an existing firm who makes business decisions on the new project. It is also reasonable to think that she makes her specific investment in the project during the time she studies the project to decide whether or not to take the project. Therefore I assume that it is only her effort in the second period that may be subject to incentive problems.

To include the extra factor of the entrepreneur's human capital, I modify the model in the following way. Denote the entrepreneur's conversion effort in the second period as e. The cost of e is $\nu(e)$, which is an increasing and convex function with $\nu(0) = 0$, the entrepreneur's conversion effort increases the final payoff by $g(e)$, i.e. $X = \theta + f(H) + g(e)$, where g(e) is an increasing and concave function.

Since the entrepreneur's investment in H is always 1, I focus my analysis on the second period. Taking the tech worker's renegotiation-proof contract as given, the residual cash flow left to the shareholder is $\theta + f(1) + g(e) - W$ in the second period.

Under debt financing, the entrepreneur is the sole shareholder. The entrepreneur's maximizing problem is:

$$\max_e \ \theta + f(1) + g(e) - \nu(e)$$

The first order condition:

$$g'(e) = \nu'(e)$$

Under equity financing, the entrepreneur needs to share her human capital value with the outside shareholder. Holding α share of the equity, the entrepreneur's maximization problem is,

$$\max_{e} \ \alpha(\theta + f(1) + g(e) - W) - \nu(e)$$

The first order of condition is:

$$\alpha g'(e) = \nu'(e)$$

The entrepreneur will exert more efforts under debt financing than under equity financing, since $g(\cdot)$ is a concave function and $\nu(\cdot)$ is a convex function. Under debt financing, all the marginal benefits of e accrues to the entrepreneur herself. Under equity financing, she has to share those marginal benefits with the outside shareholder, while bearing the cost of exerting effort alone. Therefore, debt financing is better suited to induce more human capital input from the entrepreneur.

In reality, it is not always true that levered firms have higher concentrated ownership. However, the above analysis applies in general in the following sense. Levered equity is cheaper than unlevered equity. Given the entrepreneur's wealth constraint, she is able to obtain a higher share of the levered equity than the unlevered equity. This helps to better align her incentives with the outside equityholders.

Debt financing and equity financing differ in their capacity to incentivize the entrepreneur and the tech workers. Whether or not it is optimal to use debt or equity financing depends on the following factors:

1. How important are the pecuniary incentives to the entrepreneur. It is reasonable to think that if the person who makes business decision on the project is also the founder of the firm, she will put less weight on personal monetary reward than on the success of the firm or the firm value. Therefore it is predicted that everything else equal, if the decision-maker of the firm is also its founder, more equity will be used. The following comparison might help to make the case: Microsoft and IBM are both high tech and well-established mature firms. However, the founder of Microsoft, Bill Gates is still the main decision maker at Microsoft while IBM's founders are gone. Microsoft has zero debt while IBM has a debt to equity ratio of 1.3. Similarly, the founders of Sun Microsystems and Dell are still calling shots in these firms and the firms have very low debt equity ratios.

2. The relative importance of $g(e)$ and $f(H)$. Again, this comparison stresses the main theme of this paper. That is, the more important the broad-based human capital is, the lower leverage the firm should use.

3. The cost function of specialization C. If the cost of specialization is high, it is important to provide enough incentives to the tech worker by all means. Therefore, equity financing is given higher preference. Other than individual or firm-specific factors, there are also industry or economy-wide factors that might affect this cost function. Recall that the cost of specialization not only represents the time and energy needed to gain the firm-specific knowledge, but also includes the opportunity costs related to specialization. I would imagine that such opportunity costs are particularly high when the whole economy or the industry is doing well and there are a lot of alternative employment opportunities. Therefore, according to my analysis, good times will witness more equity financing.

5.1 Managerial stock options and incentives

Granting stock options to top managers has become very popular since 1990s. Advocates of this practice praise its effectiveness in aligning the managers' incentives with that of the outside equityholders. Of course, letting managers hold stocks will serve the same purpose. Options differ from stocks in many respects due to its convex payoff structure. For the purpose of the analysis in this setting, letting managers hold stock options has at least one advantage over letting them hold equity, that is, stock options are cheaper. Given a manager's fixed wealth, she can purchase more shares of stock options than shares of stocks. Or, equivalently, the firm can grant her more shares of options at the same costs.

In last subsection, I discuss how debt can make equity cheaper and enable the entrepreneur or the manager to hold a larger share of the firm, so that she will be better aligned with the outside equityholders. On the other hand, debt has disadvantages in incentivizing the tech worker. Granting stock options to the entrepreneur in an all-equity firm seems to be a natural remedy to this conflict. Debt is not present so the tech worker is better incentivized. At the same time, the entrepreneur can hold a larger share of the firm in good states, and will want to exert more of her own human capital. But as the saying goes, "If it seems to be too good to be true, it is probably not true." Options, as they allow the entrepreneur to hold a larger share of the firm in good times and therefore encourage her to work hard, makes her incentives different from the equityholders' before the conversion.

Suppose the entrepreneur uses all equity to finance the project on date 0. Instead of holding a certain share of the equity, the entrepreneur could hold stock options. The options mature when the final cash flow X is realized, that is, on date 2 if the project is continued, on date 1 if the project is liquidated. The strike price of the options is K. If $K = 0$, then the entrepreneur holds equity. Suppose these options are exercised, the entrepreneur will hold n share of the firm, $n \in (0, 1)$. Given that the entrepreneur will be granted a fixed value of options, n is an increasing function of K, i.e., $n = n(K)$ and $n'(\cdot) > 0$. This means that the higher the strike price of the options, the cheaper each share of option. Therefore, more options will be granted to assure that the same value of options are given.

I study the incentive implications of options in two periods. Suppose the project is continued into the second period. The final cash flow will be equal to $X = \theta + f(1) + g(e)$. The tech worker will be rewarded with $W(X)$, as specified in the renegotiation-proof contract. The entrepreneur is entitle to $n * (X - W - K)$. Note that it is the entrepreneur who has made the continuation decision. The fact that she has continued the project means her options are worth something under continuation, i.e., $X - W - K \geq 0$. The entrepreneur optimizes her utility by choosing her effort level, i.e., she

$$\max_{e} \; n(\theta + f(1) + g(e) - W - K) - \nu(e)$$

The first order condition is:

$$ng'(e) = \nu'(e) \tag{5.1}$$

Denote the solution to equation 5.1 as e^*. This means that if the entrepreneur holds n of the firm, she will exert effort at a level of e^*. It is easy to show that $\frac{\partial e^*}{\partial n} > 0$. The more options the entrepreneur holds, the better the entrepreneur is incentivized and will provide more of her human capital. Since $n'(K) > 0$, it is also true that $\frac{\partial e^*}{\partial K} > 0$. Given the entrepreneur's fixed wealth (or a certain amount of costs the firm is willing to spend), the way to let the entrepreneur hold more options is to increase the strike price of her stock options and make the options cheaper. Therefore increasing the strike price encourages the entrepreneur to work harder in the second period.

The strike price of the stock options, however, also affects the entrepreneur's continuation decision and therefore affects the optimal renegotiation-proof contract. Figure 6.6 shows the payoffs to the three parties when the entrepreneur holds options with a strike price K, and a number that if converted, entitles the entrepreneur to n share of the firm. The left column displays the payoff structure if the project is continued, in either medium or high state ($\theta = \theta_m$ or θ_h). The right column displays the payoff structure if the project is liquidated. Figure 5a presents the payoff to the entrepreneur and the outside shareholders as a whole, while Figure 5b presents the payoff to the entrepreneur and the outside shareholders separately.

Unlike in the base model, the entrepreneur is not perfectly aligned with the outside equity holders for two reasons: (1) I relax the assumption that her incentives are not subject to monetary concerns. She shares the cash flow with the outside shareholder but bears all the cost of providing human capital. Therefore she will not exert as much effort as in the case where she is the sole shareholder. (2) She is now holding stock options instead of straight equity. Because of the convex payoff of the options, she can only share the upside of the cash flow distribution. The entrepreneur will continue the project only if her own payoff under continuation is not worse than under liquidation. Assuming $K > L$,[5] she will continue the project if the following is true:

$$n(\theta + f(1) + g(e) - W - K) - \nu(e) \geq 0$$

where $\theta = \theta_m$, θ_h. The renegotiation-proof constraint on W becomes:

$$W \leq \theta + f(1) - K + g(e) - \frac{1}{n}\nu(e) \tag{5.2}$$

Denote the right hand side of inequality 5.2as $F(n)$. It can be shown that $F'(n) = \frac{\nu(e^*)}{n^2} - K'(n)$. During the range where $\frac{\nu(e^*)}{n^2} < K'(n)$, increasing the number of options grants will tighten the continuation decision. As discussed in the base model, tight renegotiation-proof constraint leads to

[5] If $K < L$, the entrepreneur will always convert her options and her incentive will be the same as she is holding equity on date 1.

inferior risk-sharing between the shareholders and the tech worker. If the renegotiation constraint is too tight, it might lead to underinvestment in human capital and/or capital underinvestment.

Interpreting the entrepreneur as the top managers in the case of mature firms, granting stock options to managers can be a two-edged sword. On the one hand, it enables the managers to hold more share of the firm in good times, thus encouraging them to work hard during those times. On the other hand, it raises the bar over which the managers will continue the project. If the value created from the first effect is not as large as the continuation hurdle increase, granting options will render the non-management tech worker' compensation riskier and hurts the tech workers' incentive to specialize in the project.

The analysis in this section has the following implications. In traditional firms where only the top managers' human capital is important, granting stock options to them have positive incentive effects. However in firms with broad-based human capital, it is not clear that granting options to top managers will always increase firm value. I therefore predict that the option component in top management compensation should be lower in human-capital intensive firms.

In contrast, it is a good idea to grant options to non manager tech workers. Suppose the tech worker needs to exercise effort in applying her human capital in the second period. Letting her hold either stocks or stock options will encourage her to work harder. As discussed before, granting options is a cheaper way to align her more closely with the shareholders. On the other hand, the tech worker is not the business decision makers. Therefore options will not have the negative incentive effect on her.

6 Empirical test

In this section, I test two hypotheses that are predicted by my theory: one, human-capital intensive firms tend to have low leverage. If this is true, I should observe a significant and negative cross-sectional relationship between leverage and variables that indicate human-capital intensity, after controlling for other factors that might affect capital structure choice. Second, the more specific the firm's assets are, the stronger this negative relationship is. It is reasonable to assume that the more the firm's assets are, the more specific human capital is needed. Specific human capital cannot be easily transferred to other firms and therefore the employee has less incentive to make investment without proper compensation from the original firm.

The two regressions used to test the above two hypotheses are: for hypothesis one,

$$\frac{D}{A} = \alpha + \beta_1 HC + \beta_2 X \tag{6.3}$$

where D is the debt value and A is the asset value and $\frac{D}{A}$ is the firm's leverage ratio, HC is a proxy for human capital intensity and X is a vector of control variables. My theory predicts that β_1 be significantly negative.

For hypothesis two,

$$\frac{D}{A} = \alpha + \beta_1 HC + \beta_2 SP + \beta_3 HC * SP + \beta_4 X \tag{6.4}$$

In this regression, I add two more regressors. SP is a measure for firm specificity. I will discuss the possible candidates in section 6.6. More importantly, the other new regressor is the cross term of human-capital intensity proxy and firm specificity measure. In this setting, the partial derivative of leverage on HC is $\beta_1 + \beta_3 * SP$. If my second hypothesis is true, i.e., the more specific the firm assets are, the stronger the negative relationship between leverage and HC, then β_3 should be significantly negative.

6.1 Proxies for human-capital intensity

To test both hypotheses, I need measures for human capital intensity. I construct three proxies for human-capital intensity for my regressions. The method is demonstrated below. A firm's production inputs can be classified into three categories: capital (hard assets), low-skill labor and high-skill human capital. I denote the costs on the three types of inputs as C_k, C_l and C_h, respectively. The measure for human-capital intensity would be equal to $\frac{C_h}{C_h+C_l+C_k}$.[6] Unfortunately,

[6]Conceptually, human-capital intensity could also be measured from the production side. Ideally, if I can measure the product units that could be accrued to the three inputs, then I can measure the relative human-capital productivity. However, it is impossible to tear apart the product according to its input resources. High productivity, say, a high per capita production amount, could be attributed to human creativity or to advanced machines.

I cannot separate the cost of human capital and cost of low-skill labor with the data available. What Compustat provides is the total labor costs, which is the sum of C_h and C_l. Even if Compustat provided labor costs for different jobs, the decision as to where to draw the dividing line between these two types would be subjective, given the descriptive nature of the definition of human capital. It is widely agreed, however, that human capital, the high-skill labor, is more productive than low-skill labor and therefore will be compensated at a higher level. A firm's per capita labor costs (denoted as c hereafter) should carry information about the relative importance between human capital and low-skill labor. I make the additional assumption that the ratio of C_h relative to the total labor costs is proportional to the firm's per capita labor costs, then the human-capital intensity measure would be $c\frac{(C_h+C_l)}{C_h+C_l+C_k}$. I extend this expression to a Cobb-Douglas function as follows: $c^{\alpha}(\frac{(C_h+C_l)}{C_h+C_l+C_k})^{(1-\alpha)}$. It is hard to tell what "the" correct α value should be. Therefore I will vary α to check the robustness of the results.

I measure the human-capital intensity with a Cobb-Douglas function of two factors: one is the per capita labor costs and the other is the ratio of labor costs to total costs (or the ratio of labor costs to capital costs, since there is a one-to-one mapping between the two). Besides salaries and wages, the data item of labor costs in Compustat also includes incentive compensation, pension costs and other benefits plan, payroll taxes and profit sharing. With different relative labor costs measures, I obtain three human-capital proxies. They are: proxy 1 (denoted as HCI1): (per capita labor costs)$^{\alpha}(\frac{\text{labor costs}}{\text{capital expenditure}})^{(1-\alpha)}$, proxy 2 (denoted as HCI2): (per capita labor costs)$^{\alpha}(\frac{\text{labor costs}}{\text{costs of goods sold}})^{(1-\alpha)}$, proxy 3 (denoted as HCI3): (per capita labor costs)$^{\alpha}(\frac{\text{labor costs}}{\text{net PPE(Property, Plant and Equipments)}})^{(1-\alpha)}$.

6.2 Data description and regression specifications

I obtain accounting data between year 1962 and year 2000 from the annual Industrial Compustat database. As standard practice, I exclude commercial banks (Standard Industrial Classification (SIC) codes from 6000 to 6100) and utilities (SIC codes 4900 through 4999) because these are regulated industries. A firm-year observation is included if it contains enough nonmissing variables to run at least one regression as specified below. For example, I have four measures of leverage and three measures of human-capital proxies. For an observation to be included, it has to have at least one measure of leverage and one proxy of human-capital intensity not missing, besides having all other control variables available. The sample thus contains 5290 observations. (The number of observations used in each regression varies a little bit under different measures of leverage and human-capital intensity proxies.) I also perform the same analysis including the regulated firms and the results (not reported) remain qualitatively the same.

The sample size is significantly reduced due to the lack of data on labor costs, which is needed to construct proxies of human-capital intensity.[7] This item is voluntarily disclosed. According to Ballester, Livnat and Sinha (2001), only 10% of firms in Compustat consistently identify labor costs, another 30% report these costs in some but not all years. Larger firms, firms in less concentrated industries and firms in labor-intensive industries tend to disclose labor costs more often.

Compustat contains only publicly-traded firms and does not have data on private firms or startup firms. That biases my sample toward large firms and relatively mature firms. The data requirement of labor costs further tilts the sample in that direction, for the reason described above. Two questions might arise: one, does my theory apply to large and mature firms? Two, can the results of the test on large firms be applied to other firms?

It may be argued that my theory is less applicable to large firms because there are people in different stages of their human capital development in a large firm and the effects tend to be canceled off. However, capital structure is the cumulative outcome of past financing decisions. Each time a firm starts a new project that needs to be financed, its employees may need to build human capital specific to that project. Therefore the incentive problem as described before presents itself in the financing decision. Thus, human-capital intensity is a determinant for financing method in each financing round. It must also drive (in the same direction as it does on each financing round) the accumulation of the financing decisions, the capital structure.

Because the sample is biased toward large and public firms, there is a chance that the results of this test might not apply to small and private firms. But to the extent that the argument is true, that there is less noise in applying my theory to small startup firms since most employees are probably in the same stage of human capital development cycle, supporting evidence obtained

[7] There are 49645 observations that contain nonmissing variables other than human-capital proxies. After imposing the requirement that at least one human-capital intensity proxy can be calculated, there are only 5290 firm-years left.

from tests using large firms suggests stronger results.

Table 1 lists the dependent and explanatory variables in my capital structure regressions. Four measures of leverage are used in this study. They are long-term debt and total debt divided by book value of assets and market value of assets. The market value of assets is defined as book value of assets minus book value of common equity plus market value of common equity.

The proxies of human-capital intensity are the focus of interest of the analysis. However, as is well known, there are other factors that affect capital structure. Harris and Raviv (1991) present a nice survey on both theoretical and empirical studies on determinants of capital structure. Here I follow Berger, Ofek and Yermack (1997) to include the following fairly comprehensive list of variables that the literature expects to affect capital structure. Results by varying control variables are discussed in the robustness check.

Myers (1977) describes how shareholders might invest suboptimally given debt obligations. This is often interpreted as a reason that growth firms should be financed with equity rather than debt. Two measures are used to control for firm growth opportunities, Tobin's Q and R&D expenses. Tobin's Q is measured as the book value of assets minus book value of common equity plus market value of common equity, divided by book value of assets. R&D expenses are standardized by sales.

Conventional wisdom predicts that firms can borrow more debt if it has more assets that can be collateralized. See Brealey and Myers for more discussion. The collateral value of assets is measured by the ratio of net property, plant and equipment plus total inventories over assets.

Titman (1984), Jaggia and Thakor (1994) predict that the more specific a firm's assets are, the less debt the firm should use. Titman and Wessels (1988) use two measures for firm's specificity: selling, general and administrative expenses (SGA) and R&D expenses. They are standardized by sales.

DeAngelo and Masulis (1980) argue that the tax shield value of debt depends on the availability of non debt tax shields in a firm and its need for tax shields. The more non debt tax shield there is, the less debt is needed. I control for non debt tax shield by using investment tax credit over assets. Profitability is a measure for the need for tax shield. The more profitable a firm is, the more debt is valuable in providing tax shield.

However, according to the pecking order theory of capital structure, more profitable firms will use less debt. Myers (1984) and Myers and Majluf (1984) study the firm's capital structure choice in an asymmetric information setting. If the firm's managers or existing shareholders know more about the firm than the new financial investors, issuing equity could send a bad signal about the firm value. Therefore the firm would prefer to use internal funds first, then issue debt and finally issue equity. A profitable firm has less need to borrow. See Shyam-Sunder and Myers (1999) and Fama and French (2000) for more discussion on the contrasting predictions of the pecking order theory and the trade-off theory of capital structure. I measure firm profitability with earnings before interest, depreciation and tax (EBITDA) over assets value.

Finally, firm size is included as a control variable. Large firms tend to be less volatile. The bankruptcy risk is therefore lower and hence supports more debt. Smith and Watts (1992) and Fama and French (2000) discuss size effect on capital structure. I measure firm size by using the logarithm of assets.

Table 2 displays the correlations between all the explanatory variables in the sample. The three proxies for human-capital intensity have low correlation with other explanatory variables.

6.3 Univariate tests

Before I present the multiple regressions, in this section I present the univariate comparisons of firms' leverage levels by quartiles of human-capital intensity proxies. I am interested to know if human-capital intensive firms, such as the firms in the fourth quartile, differ in leverage level from those firms that are not human-capital intensive, such as the firms in the first quartile. I test the hypothesis that leverage levels differ between firms in the fourth quartile and firms in the first quartile with a t-test.

Table 3 displays the mean (and median values in the parentheses) leverage ratios in each quartile of human-capital intensity proxies. In the last column, the difference of the mean value between the fourth quartile and first quartile is calculated and the t-statistic is shown in the parenthesis beneath. Since results are very similar for different values of alpha, I only present results with $\alpha = 0.5$. There are three panels in the table. Each panel's quartiles are based on one human-capital intensity measure. Under each human-capital intensity measure, all four measures of leverage are compared between the fourth and the first quartiles. It turns out that the average leverage does not always decrease monotonically across quartiles, so that comparing leverage between the first quartile and the fourth quartile may not be sufficient to describe the relationship between the leverage and human-capital intensity.

Leverage for firms in the first quartile of human-capital intensity differs significantly from that of firms in the fourth quartile. The mean leverage level in the fourth quartile is always lower than the mean leverage level in the first quartile. For all but one combination of leverage measures and human-capital intensity proxies, the difference is significant at 10% level. The average magnitude of difference is 3.5%, 4.6% and 7.9%, under each human-capital proxy respectively. For comparison, I also run similar univariate tests based on quartiles of other capital structure determinants. As documented in other empirical papers and shown in later part of this empirical test, the collateral value of assets, firm profitability, R&D expenses and firm size have the strongest explanatory power for leverage of all the control variables. On average (across different measures of leverage), the mean leverage ratio in the fourth quartile of collateral value is higher than that in the first quartile by 7.6%. The mean leverage ratio in the fourth quartile of profitability is 14% lower than that in the first quartile. The mean leverage ratio in the fourth quartile of R&D expenses is 7.2% lower than that in the first quartile. The mean leverage ratio in the fourth quartile of firm size is 1% higher than that in the first quartile.

6.4 Alternative regression models

I consider several regression methods to estimate model 6.3. They are Fama-MacBeth approach, pooled OLS regression, between-firm regression and within-firm regression.

The first regression model uses the method presented in Fama-MacBeth (1973). With this approach, the cross-sectional regression in equation 6.3 is run for each year and the significance of the averaged coefficients is tested. The Fama-MacBeth regression eliminates the problem of serial correlation of the error terms in a time-series cross-sectional regression. It effectively treats each year as an independent cross-sectional regression.

Pooled OLS assumes independence across error terms and produces consistent estimates. The GLS regression could be run if we take into account panel-heteroskedasticity and/or serial correlation.

The between-firm regression estimates the cross-sectional regression using the mean values of the regression variables across sample years for each firm.

The last alternative regression model is the within-firm regression which adds firm dummies to the pooled regression. The coefficients estimated from the within-firm regression are equivalent to the coefficients from regressions using de-firm-meaned variables. This regression method tests the relationship between the dependent variable and the independent variable over time for the same firm as well as cross-sectionally, hence the name of the method.

Both the Fama-MacBeth model and the between-firm regression emphasize the cross-sectional relationship, the former averages the results from the cross-sectional regression for each year and the latter runs the collapsed cross-sectional regression. On the other hand, both the pooled OLS and the within-firm regression test a regressor's explanatory power both cross-sectionally and across-years within the same firm. The within-firm regression allows for a different regression intercept for each firm.

My theory predicts a cross-sectional relationship, that is, human-capital intensive firms tend to have high leverage. It has less time-series predicting power. For one thing, firms might have temporary workforce reduction for cost-saving purposes. This will lead to changes in the value of my human-capital intensity proxies, but it does not necessarily change a human-capital intensive firm to a non human-capital intensive firm, or vise versa. Therefore its financial structure does not necessarily change either. There might be also environmental changes over time such as changes in tax codes that will affect the capital structure choices independently of the factors I control in the regression. Although I also find supporting evidence using the pooled OLS and the within-firm regression, I prefer to focus on results from a cross-sectional method. I have the additional option of studying and comparing each year's results by using the Fama-MacBeth method, as opposed to using the between-firm regression. Therefore the Fama-MacBeth estimates will be presented as my main results. Regression results from other methods will be discussed as well.

6.5 Regression results

In this section I first analyze the results from the Fama-MacBeth regressions then display the results from alternative regression methods. Under the Fama-MacBeth approach, the same cross-sectional regression is run for each year. I only include a regression if it has at least 30 observations. This requirement excludes year 1962, 1963 and 1964 from the sample,[8] and leaves me with 36 years of data (year 1965 to 2000). Each regression includes industry dummies, with an industry defined by its first two-digit SIC code. Each regression also adjusts for heteroskedasticity with White's (1980) correction. The first three years of observations are added back in the alternative regressions.

Figures 2 and 3 display the histograms of coefficients and t-statistics of human-capital proxies from yearly cross-sectional regressions. To show the distribution of these yearly regression results, I put together the results of 1296 regressions (36 years * 4 measures of leverage * 3 measures of human-capital proxies * 3 values of α). The coefficients are not all comparable across regressions. However, the distribution of their signs can convey some information on whether or not my theory is valid. The t-statistics are comparable. As can be seen from both figures, the regression coefficients are overwhelmingly negative. In fact, 82% of the regressions have negative coefficients. Thirty-seven percent of the coefficients are negative and significant at the 10% level. Among the positive coefficients, only 4 out of 1296 are significant at the 10% level. Moreover, I also run a regression of the t-statistic of each regression on the observation number of that regression. There is a strong negative relationship between the two. It indicates that more reliable regressions with more observations will likely display the negative relationship between leverage and human-capital intensity.

Table 4 through Table 7 present the average coefficients of each set of 36 regressions (with fixed measure of leverage, human-capital intensity proxy and α) and their t-statistics. T-statistics are calculated based on the standard deviation of the 36 yearly estimates.

Each table has the same explanatory variables but a different measure of the dependent variable, i.e., a different measure of the leverage. Table 4 displays results with the dependent variable as the book value of long-term leverage; Table 5 with the market value of long-term leverage; Table 6 with the book value of total leverage and Table 7 with the market value of total leverage.

Each table contains three parts with different values of alpha, which is the power of per capital labor costs in the Cobb-Douglas function of human-capital proxy measures, i.e., $c^{\alpha}(\frac{(C_h+C_l)}{C_h+C_l+C_k})^{(1-\alpha)}$. Recall that in measuring human-capital intensity, I try to balance two considerations: one is the

[8]Each of these years contain 27, 19 and 22 observations, respectively.

importance of labor against capital, the second is the proportion between human capital to low-skill labor. The higher the value of α, the more confident I am that high values of proxies are associated with firms abundant in human capital instead of low-skill labor. Column (1) - (3) display regression results with human-capital proxies measured with $\alpha = 0.25$, columns (4)-(6) with $\alpha = 0.5$ and the last three columns with $\alpha = 0.75$. Under each of these three parts, each column stands for regression results run with one human-capital proxy.

The four tables display quite consistent results. In particular, the following results are true under all measures of leverage. High collateral value leads to high leverage. This is consistent with the conventional wisdom that a high collateral value implies lower bankruptcy costs and therefore supports more debt. High level of R&D expenses are associated with low leverage. This is consistent with two alternative theories, one is that R&D is a proxy for growth opportunity and that firms with high growth opportunity tend to have low leverage; the other suggests that R&D is a measurement of the uniqueness of firm assets and that firms with more specific assets tend to have low leverage (Titman and Wessels, 1988). Highly profitable firms tend to have low leverage, which is consistent with the results in Fama and French (2000). This result supports the pecking order theory which predicts that firms will use internal funds first before seeking outside funds. It is inconsistent with the static trading-off theory which states profitable firms needs more tax shield from debt. Firm size also has strong prediction power for leverage. Large firms tend to have more debt. This could be due to the fact that large firms are more diversified and the expected bankruptcy costs are lower. The coefficients of the above explanatory variables are all highly significant.

The remaining three regressors other than human-capital proxies yield mixed results. Theories predict that firms with high growth opportunity tend to have low leverage. As the most commonly used proxy for growth opportunity, Tobin's q is predicted to be negatively related with leverage. Empirical papers such as Titman and Wessels (1988) find that it is negatively related to market value leverage measures, but positively related with book value leverage measures. My results from the OLS regressions, the between-firm regressions and within-firm regressions confirm their findings. With the Fama-MacBeth regressions, I find that Tobin's q is significantly negatively associated with market value leverage measures, but it is also negatively associated with book value leverage measures, although the coefficients are all insignificant. A big advantage of using debt is its tax shield value. If a firm has lots of non debt tax shield value, then the incentives to using debt is reduced. Therefore it is predicted that high non tax shield leads to low debt. The results found here are inconsistent with this prediction. With three measures of leverage, that is the book value of total leverage, the market value of long-run and total leverage, the coefficients of non debt tax shield are all insignificant and most of them are positive. Its coefficients under the book value of long-run leverage are significant but all of them are positive. My interpretation of this is that non debt tax shield simply does not have much explanatory power over leverage, given the other regressors. SGA expenses is another measure for firm uniqueness and Titman and Wessels (1988) predicts that it should be negatively associated with leverage. I find mixed results for this regressor. With market value leverage its coefficients are mostly insignificant and have mixed signs. With book value of long-term leverage its coefficients are positive and mostly insignificant. With book value of total leverage most of its coefficients are significantly positively. Thus, the relationship between leverage and SGA is not robust. As a matter of fact, SGA expenses include R&D expenses and the two have a high correlation. I later drop SGA from my regressions and confirm that does not change my main results.

The focus of the testing, of course, is the relationship between leverage and human capital intensity and how robust that relationship is. The results on Table 4 to Table 7 show that there is a negative relationship between leverage and human-capital intensity and this negative relationship is very robust under different measures of leverage and proxies of human capital intensity. Out of the 36 sets of regressions I run, all average coefficients of human capital intensity proxies are negative and all but one are significant at the 10% level. Most of them are highly significant. [9]

In testing the significance of the averaged coefficients, the Fama-MacBeth method treat coefficients from each year's cross-sectional regression with equal weight. It does not take into account the strength or reliability of each regression. I address this problem by presenting a modified test. In the Fama-MacBeth method, a t-statistic is constructed to be the averaged coefficient divided by its standard deviation, which is the standard deviation of the coefficients divided by $\sqrt(n)$, i.e., $t = \frac{\bar{X}}{\sigma_X / \sqrt(n)}$, where X is the coefficient of a regressor from each yearly regression, $\bar{X}$ is the averaged

[9]It is suggested that when R&D expenses are not reported, they are usually close to zero. I then run the same regression setting R&D expenses to zero if they are not reported. I obtain similar results.

coefficient, σ_X is its standard deviation and n is the number of regressions and equal to 36 here.

Under the modified Fama-MacBeth approach, I test the significance of the averaged standardized (by standard errors of estimation) coefficients . Assuming normality and independence across regressions, the averaged standardized coefficient is normally distributed with a mean of zero and a standard deviation of $1/\sqrt(n)$, if the null hypothesis is true that the independent variable does not affect the dependent variable. Hence, the modified t-statistic is $t = \sqrt(n)(\overline{\frac{X}{\sigma_X}})$, where σ_X is the standard error of X in each regression estimation. Under this modified approach, an insignificant but large coefficient estimate will receive little weight in constructing the t-statistic, while it will receive equal weight as other significant estimates in the original Fama-MacBeth approach. Table 8 displays the t-statistics for human-capital intensity proxies under various regression specifications. In general, the results are even stronger than those under the original Fama-MacBeth approach.

I have shown that the coefficients of the human-capital are statistically significant. But how much variation of leverage do they help to explain and what is their economic significance? The univariate analysis in section 6.3 gives some idea to answer this question. Moving from the first quartile of human-capital proxy to the fourth quartile, the average (across leverage measures) mean leverage ratio drops by 3.5%, 4.6% and 7.9%, under each human-capital proxy respectively. These numbers are comparable to the changes due to collateral value of assets, firm profitability, R&D expenses and firm size.

To answer the question more directly, I calculate the ratio of regression coefficients times standard deviation of a regressor to the standard deviation of a leverage measure, as a direct measure of variation explained by that regressor. These ratios do not add up to 1 across regressors because they are ratios of standard deviation instead of variance. Table 9 compare this ratio across important regressors under book (and market) value of long-term leverage and assuming $\alpha = 0.5$. The variation of the book value of long-term leverage explained by the three human-capital intensity proxies is 11%, 12% and 17%, respectively. The variation of market value of long-term leverage explained by the three human-capital intensity proxies is 10%, 18% and 29%, respectively. They are very close to the explanatory ability of collateral value of assets and R&D expenses, and always higher than that of firm size. The variation explained by firm profitability seems to be the highest. But under the market capital structure, the extraordinary high variation explained by profitability is partially due to the positive correlation between profitability and the market value of equity.

I also examine the absolute changes in leverage ratios with a change of one standard deviation of a human-capital intensity proxy. Results are displayed in Table 10. One standard deviation of human-capital intensity proxies leads to changes in book value of long-term leverage by 3.2%, 3.5% and 4.8%, respectively. The corresponding numbers for the market value of long-term leverage are 1.3%, 2.4% and 3.7%. Again, they are comparable with the corresponding changes due to the other important capital structure determinants, with the exception of profitability.

Finally, I run the other three types of regressions discussed in section 6.4 and find supporting results. Results are similar for different values of α. They are also similar for the two measures of book (market) value leverage. Hence I only present the results for the book (market) value of long-term leverage ratio and for $\alpha = 0.5$ in Table 11 (Table 12).

The first three columns of Table 11 and Table 12 contain results from pooled time series and cross sectional regressions with dummies for year and industry. The next three columns show results from between-firm regressions, with dummies for industry. The results from within-regression are displayed in the last three columns. All t-statistics in the parentheses are corrected for heteroskedasticity. I also try to adjust autocorrelation for the pooled OLS regressions and the within-regressions. I run these two types of regressions assuming an AR(1) error structure and find strong supporting results (not reported here).

I find supporting evidence in the alternative regressions. All the coefficients of human-capital intensity proxies are negative. With the book value of long-term leverage, only one estimate is insignificant at the 10% level and most of them are significant at 5% level. With the market value of long-term leverage, there are 3 coefficients of human-capital proxies are insignificant at the 10% level, one of which is on the borderline with a t-statistic of 1.63. Recall that I have applied the two-sided test. It is a more strict test than the one-sided test, which is also valid given my theoretical prediction.

Other than the consistent results for human-capital proxies, the three alternative methods also produce consistent results for explanatory variables such as collateral value and profitability, whose coefficients are mostly significant in all the regressions and have the same signs as in the Fama-MacBeth approach. Unlike under the Fama-MacBeth approach, Tobin's Q now displays significant and positive associations with book value of leverage measures and significant and negative associations with market value of leverage measures. The coefficients of non debt tax shield and SGA expenses have mixed signs under different regression methods and they are mostly insignificant.

We find strong and consistent results for both firm size and R&D under the Fama-MacBeth approach. However, the current results are mixed. Coefficients of firm size are significantly positive under OLS regressions and within-firm regressions. But under between-firm regressions, they are insignificant with book value of leverage measures but positive and significant with market value of leverage measures. R&D expenses are still negatively related with leverage in OLS and between-firm regressions but are less significant than under the Fama-MacBeth approach. Under within-firm regressions, while the coefficients are significantly negative for market value of leverage measures, they become positive and insignificant for book value of leverage measures. [10] As discussed before, this weakened impact of R&D could be due to the fact that temporary changes in R&D expenses do not necessarily change the firm's growth opportunity or uniqueness, neither do they change the leverage.

To the extent that my proxies are good measures of human-capital intensity, I find that human-capital intensity leads to low leverage.

6.6 Firm specificity and the impact of human capital intensity on capital structure

I estimate equation 6.4 in this section. I use two measures of firm specificity. [11] The first one is R&D expenses, which is already included in regression 6.3. The second one is Robert Parrino's (1997) correlation measure for industry homogeneity. It is fairly straightforward to use R&D as a proxy for firm specificity. The more independent research a firm conducts, the more likely that it produces unique products. For the details of Parrino's industry homogeneity measure, please see Parrino (1997). Given that the higher the correlation measure, the more homogeneous the industry is and the less specific each firm within the industry, the less negative the relationship between

[10] This is also true for regressions without a human-capital intensity proxy.

[11] I considered another two measures for firm specificity: advertisement expenses (suggested by Long and Malitz (1985)) and SGA expenses (suggested by Titman and Wessels (1988)). I found supporting evidence with these two measures.

the leverage and human-capital intensity should be. Note that R&D is a positive measure for firm specificity while industry correlation is an inverse measure for firm specificity, i.e., higher industry correlation means lower firm specificity. Therefore β_3 in equation 6.4 associated with R&D should be negative and β_3 associated with industry correlation should be positive, to be consistent with hypothesis two.

Table 13 and 14 display estimation results of equation 6.4 using Fama-MacBeth method. I only show results with long-term leverage measures and assuming α equal to 0.5 for the human-capital intensity proxies. Results associated with alternative independent variables and alternative α values are similar.

In Table 13, the firm specificity is measured by R&D. The cross-term coefficients for both human-capital proxy 1 and 3 are significant and negative at 10% level, as predicted by hypothesis two. The cross-term coefficients for human-capital proxy 2 have mixed signs and are not significantly different from zero. The coefficients for human-capital intensity proxies themselves remain significantly negative, with one exception. Interestingly, the coefficients of R&D itself become mostly insignificant.

In Table 14, firm specificity is measured by industry correlation. As predicted by the second hypothesis, the cross-term coefficients are all positive and significant at 1% level. The coefficients of human-capital intensity themselves are negative and highly significant.

Another interesting aspect in this estimation is the coefficients on industry correlation. They are all negative and highly significant at 1% level. By including a variable for industry homogeneity, I also conduct a direct test of Shleifer and Vishny (1992) theory of capital structure. In that paper, they take an equilibrium approach to study capital structure. The idea is that when a firm needs to liquidate its assets, the potential buyers from the same industry might be experiencing financial difficulty themselves and therefore cannot afford a high bidding price. As a result, concerns of low liquidation value will make the firm use less debt. Shleifer and Vishny use stylized facts to support their theory. But Table 14 provides evidence that supports it directly. The more correlated an industry is, the more likely they will experience financial distress during the same period. That means liquidation value will be low for firms in the industry when they need to sell. Therefore a highly correlated industry should use less debt. The significant and negative coefficients on industry correlation in the capital structure regression support this theory.

In short, empirical tests support my theory that human-capital intensity is another important capital structure determinant. The relationship between leverage and human-capital intensity depends on firm-specificity.

References

Ballester, Marta and Joshua Livnat and Nishi Sinha, 2001, "Labor Costs and Investments in Human Capital," working paper, New York University.

Baker, Malcolm and Jeffrey Wurgler, 2000, "Market Timing and Capital Structure," working paper, Yale University.

Becker, Gary. S., 1962, "Investment in Human Capital: a Theoretical Analysis," *Journal of Political Economy* 70(5) supplement, 9-49.

Becker, Gary. S., 1964, *Human Capital* New York: Columbia University Press.

Berger, Philip G., Eli Ofek and David Yermack, 1997,"Managerial Entrenchment and Capital Structure Decisions", *Journal of Finance* 52, 1411-1438.

Berkovitch, Elazar, Ronen Israel and Jaime F. Zender, 1997, "Optimal Bankruptcy Law and Firm-Specific Investments," *European Economic Review* 41, 487-497.

Ben-Porath, Yoram, 1967, "The Production of Human Capital and the Life Cycle of Earnings," *Journal of Political Economy*, 75(4), 352-365.

Burkart, Mike, Denis Gromb and Fausto Panunzi, 1997, "Large Shareholders, Monitoring and the Value of the Firm," *Quarterly Journal of Economics*, 693-728.

Dybvig, Philip and Jaime Zender, 1991, "Capital Structure and Dividend Irrelevance with Asymmetric Information," *Review of Financial Studies* 4(1), 201-219.

DeAngelo, Harry and Ronald Masulis, 1980, "Optimal capital structure under corporate and personal taxation," *Journal of Financial Economics* 8, 3-29.

Fama, Eugene F. and Kenneth R. French, 2000, "Testing Tradeoff and Pecking Order Predictions About Dividends and Debt," working paper, University of Chicago.

Fama, Eugene F. and James D. MacBeth, 1973, "Risk, Return, and Equilibrium: Empirical Tests," *Journal of Political Economy* 81, 607-636.

Gibbons, Robert and Kevin J. Murphy, 1992, "Optimal Incentive Contracts in the Presence of Career Concerns: Theory and Evidence," *Journal of Political Economy* 100(3), 468-505.

Grossman, Sanford J. and Oliver D. Hart, 1986, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration,"*Journal of Political Economy* 94(4), 691-719.

Hart, Oliver and John Moore, 1990, "Property Rights and the Nature of the Firm," *Journal of Political Economy* 98(6), 1119-1158.

Harris, Milton and Artur Raviv, 1991, "The Theory of Capital Structure," *Journal of Finance* 46(1), 297-355.

Hart, Oliver and John Moore, 1994, "A Theory of Debt Based on the Inalienability of Human Capital," *Quarterly Journal of Economics* 109(4), 841-879.

Hart, Oliver and John Moore, 1998, " Default and Renegotiation: A Dynamic Model of Debt," *Quarterly Journal of Economic* 113(1), 1-41.

Holmstrom, Bengt, 1979, "Moral Hazard and Observability," *Bell Journal of Economics* 74-91.

Holmstrom, Bengt and John Roberts, 1998, "The Boundaries of the Firm Revisited," *Journal of Economic Perspectives* 12(4), 73-94.

Jaggia, Priscilla B. and Anjan V. Thakor, 1994, "Firm-Specific Human Capital and Optimal Capital Structure," *International Economics Review* 35(2), 283-308.

Klein, Benjamin, Robert Crawford, and Armen Alchian, 1978, "Vertical Integration, Appropriable Rents, and the Competitive Contracting Process," *Journal of Law and Economics* 21, 297-326.

Levy, Amnon, 2000 "Why Does Capital Structure Choice Vary with Macroeconomic Conditions?" working paper, New York University.

Long, Michael S. and Ileen B. Malitz, 1985, "Investment Patterns and Financial Leverage," Corporate Capital Structures in the United States, Benjamin M. Friedman ed., The University of Chicago Press.

Mincer, Jacob, 1962, "On the Job Training Costs: Costs, Returns and some other Implications," *Journal of Political Economy* 70(2) supplement, 76-108.

Myers, Stewart C., 1977, "Determinants of Corporate Borrowing," *Journal of Financial Economics* 5, 147-175.

Myers, Stewart C., 1984, "The Capital Structure Puzzle," *Journal of Finance* 39, 575-592.

Myers, Stewart C., and Nicholas S. Majluf, 1984, "Corporate Financing and Investment Decisions When Firms Have Information That Investors Do Not Have," *Journal of Financial Economics* 13, 187-221.

Myers, Stewart C., 1999, "Financial Architecture," *European Financial Management* 5(2), 133-141.

Parrino, Robert, 1997, "CEO Turnover and Outside Succession: A Cross-Sectional Analysis," *Journal of Financial Economics* 46, 165-197.

Perotti, Enrico and Kathryn Spier, 1993 "Capital Structure as a Bargaining Tool: the Role of Leverage in Contract Renegotiation," *American Economic Review* 83(5), 1131-1141.

Rajan, Raghuram and Luigi Zingales, 1995, "What Do We Know about Capital Structure? Some Evidence from International Data," *Journal of Finance* 50(5), 1421-1460.

Rajan, Raghuram and Luigi Zingales, 1998, "Power in a Theory of the Firm," *Quarterly Journal of Economics* 113(2), 387-432.

Rajan, Raghuram and Luigi Zingales, 2000, "The Governance of the New Enterprise," Xavier Vives ed., Corporate Governance, Cambridge University Press.

Rajan, Raghuram and Luigi Zingales, 2001, "The Influence of the Financial Revolution on the Nature of Firms," *American Economic Review* 91(2), 206-211.

Ravid, S. Abraham and Matthew Spiegel, 1997, "Optimal Financial Contracts for a Start-Up with Unlimited Operating Discretion," *Journal of Financial and Quantitative Analysis* 32(3), 269-286.

Rosen, Sherwin, 1972, "Learning and Experience in the Labor Market," *Journal of Human Resources* 7, 326-342.

Ross, Stephan A., 1973, "The Economic Theory of Agency: The Principal's Problem," *American Economic Review* 62, 134-139.

Ryder, H., E. Stafford and P. Stephan, 1976, "Labor Leisure and Training over Life Cycle," *International Economic Review* 17, 651-674.

Sarig, Oded H., 1998, "The effect of Leverage on Bargaining with a Corporation," *Financial Review* 33, 1-16.

Schmidt, Klaus, 2000, "Convertible Securities and Venture Capital Finance," working paper, University of Munich and CEPR.

Schultz, Theodore W., 1962, "Reflections on Investment in Man," *Journal of Political Economy* 70(2) supplement, 1-8.

Shleifer Andrei and Lawrence H. Summers, 1988, "Breach of Trust in Hostile Takeovers," Corporate Takeovers: Causes and Consequences, Alan J. Auerbach ed., University of Chicago Press.

Shleifer Andrei and Robert W. Vishny, 1989, "Management Entrenchment the Case of Manager-Specific Investments," *Journal of Financial Economics* 25, 123-139.

Shleifer Andrei and Robert W. Vishny, 1992, "Liquidation Values and Debt Capacity: A Market Equilibrium Approach," *Journal of Finance* 47(2), 1343-1366.

Shyam-Sunder, Lakshmi and Stewart Myers, 1999, "Testing Static Tradeoff against Pecking Order Models of Capital Structure," *Journal of Financial Economics* 51, 219-244.

Smith, Clifford W., Jr. and Ross L. Watts, 1992, "The Investment Opportunity Set and Corporate Financing, Dividend, and Compensation Policies," *Journal of Financial Economics* 32, 263-292.

Titman, Sheridan, 1984, "The Effect of Capital Structure on a Firm's Liquidation Decision," *Journal of Financial Economics* 13, 137-151.

Titman, Sheridan and Roberto Wessels, 1988, "The Determinants of Capital Structure Choice," *Journal of Finance*, 43(1), 1-19.

Weiss, Yoram, "The Determination of Life Cycle Earnings: A Survey." Handbook of Labor Economics, vol 1, ed. O. Ashenfelter and R. Layard.

Williamson, Oliver E., 1975, *Markets and Hierarchies: Analysis and Antitrust Implications.* The Free Press, New York.

Williamson, Oliver E. 1985, *The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting.* The Free Press, New York.

Zingales, Luigi, 2000, "In Search of New Foundations," *Journal of Finance* 55(4), 1623-1653.

Table 1: Definition of Variables

Dependent variables	Definition
long-term leverage (book value)	long-term debt÷ asset value
long-term leverage (market value)	long-term debt÷(asset value- book value of common equity + market value of common equity)
total leverage (book value)	(long term debt + debt in current liabilities)÷ asset value
total leverage (market value)	(long term debt + debt in current liabilities)÷(asset value- book value of common equity + market value of common equity)

Independent variables	Definition
q	(asset value- book value of common equity + market value of common equity)÷ asset value
collateral value of assets	(net property, plant and equipment + inventories)÷ asset value
R&D expenses	research and development expenses÷ sales
profitability	earnings before interest, taxes and depreciation ÷ asset value
non debt tax shield	investment tax credits÷ asset value
sga expenses	selling, general and administrative expenses÷ sales
firm size	log(asset value)
HCI1	$(\text{per capita costs})^{\alpha}(\frac{\text{labor costs}}{\text{capital expenditure}})^{(1-\alpha)}$
HCI2	$(\text{per capita costs})^{\alpha}(\frac{\text{labor costs}}{\text{costs of goods sold}})^{(1-\alpha)}$
HCI3	$(\text{per capita costs})^{\alpha}(\frac{\text{labor costs}}{\text{net PPE}})^{(1-\alpha)}$

Table 2: Correlation of Explanatory Variables

This table displays the correlation between the explanatory variables in the regression model 6.3. It is based on the sample of 5290 firm years from year 1962 to 2000 The probability that the correlation is zero is shown in the parentheses.

	q	clatrl	R&D	profit	taxshld	sga	firm size	HCI1	HCI2	HCI3
q	1									
clatrl	-0.19 (0.00)	1								
R&D	0.30 (0.00)	-0.28 (0.00)	1							
profit	-0.39 (0.00)	0.15 (0.00)	-0.46 (0.00)	1						
taxshld	-0.08 (0.00)	0.27 (0.00)	-0.09 (0.00)	0.13 (0.00)	1					
sga	0.42 (0.00)	-0.20 (0.00)	0.59 (0.00)	-0.48 (0.00)	-0.10 (0.00)	1				
firm size	-0.07 (0.00)	0.10 (0.00)	-0.09 (0.00)	0.22 (0.00)	0.01 (0.44)	-0.18 (0.00)	1			
HCI1	0.08 (0.00)	-0.35 (0.00)	0.16 (0.48)	-0.31 (0.00)	-0.18 (0.00)	0.13 (0.00)	-0.14 (0.00)	1		
HCI2	0.27 (0.00)	-0.31 (0.00)	0.39 (0.00)	-0.29 (0.00)	-0.08 (0.01)	0.40 (0.00)	0.00 (0.90)	0.53 (0.00)	1	
HCI3	0.14 (0.00)	-0.52 (0.00)	0.25 (0.02)	-0.31 (0.00)	-0.14 (0.00)	0.17 (0.00)	-0.14 (0.00)	0.80 (0.00)	0.49 (0.00)	1

Table 3: Univariate Test

Univariate comparison of means and medians of leverage ratios by the quartiles of the human-capital intensity measures. Median values are in parentheses. Calculations are based on the sample of 5290 firm years from year 1962 to 2000. In Panel 1, the data is divided according to the quartiles of human-capital intensity proxy 1. Panel 2 is based on the quartiles of human-capital intensity proxy 2 and panel 3 is based on human capital intensity proxy 3. The difference of the mean leverage ratio (or the human-capital intensity measure) between the fourth quartile and the first quartile is calculated and the t-statistic is shown in the parentheses.

	1st quartile	2nd quartile	3rd	4th	difference
panel 1					
HCI1	4.2082	7.4502	10.4253	17.5106	13.3025
	(4.4119)	(7.4512)	(10.3691)	(15.0225)	(46.2685)
book long-term leverage	0.209	0.1742	0.1623	0.1662	−0.0428
	(0.2023)	(0.1753)	(0.1592)	(0.1392)	(−2.8074)
market long-term leverage	0.1736	0.1643	0.1577	0.1367	−0.0368
	(0.1547)	(0.1544)	(0.1382)	(0.1146)	(−7.3957)
book total leverage	0.2516	0.2196	0.2087	0.2198	−0.0317
	(0.2439)	(0.2204)	(0.2031)	(0.186)	(−2.0374)
market total leverage	0.2082	0.2052	0.1997	0.1805	−0.0277
	(0.1873)	(0.1961)	(0.1824)	(0.1521)	(−4.887)
panel 2					
HCI2	1.4871	2.2056	2.8521	4.7313	3.2442
	(1.5728)	(2.2012)	(2.8304)	(3.9763)	(33.6349)
book long-term leverage	0.1955	0.185	0.1657	0.1654	−0.0301
	(0.1859)	(0.1843)	(0.1628)	(0.1312)	(−1.9425)
market long-term leverage	0.1776	0.1804	0.1565	0.1173	−0.0604
	(0.1601)	(0.1717)	(0.1408)	(0.091)	(−12.7228)
book total leverage	0.243	0.231	0.2081	0.2175	−0.0254
	(0.2288)	(0.2298)	(0.2051)	(0.1868)	(−1.6118)
market total leverage	0.2221	0.2237	0.193	0.1545	−0.0676
	(0.1975)	(0.2124)	(0.1754)	(0.1289)	(−12.3121)
panel 3					
HCI3	1.9646	3.3133	4.5825	7.6619	5.6972
	(2.0789)	(3.308)	(4.5478)	(6.5261)	(53.3222)
book long-term leverage	0.2255	0.1761	0.1643	0.1456	−0.0799
	(0.2151)	(0.1799)	(0.165)	(0.1183)	(−5.1501)
market long-term leverage	0.193	0.1695	0.1585	0.1108	−0.0822
	(0.1705)	(0.1647)	(0.1435)	(0.0901)	(−16.95)
book total leverage	0.2684	0.22	0.2152	0.1961	−0.0723
	(0.2533)	(0.2229)	(0.211)	(0.1626)	(−4.5672)
market total leverage	0.229	0.2095	0.2043	0.1504	−0.0786
	(0.2034)	(0.2014)	(0.1921)	(0.1251)	(−14.2689)

Table 4: Fama-MacBeth Regression

This table displays regression results from the Fama-MacBeth regression, with the dependent variable as the book value of long-term leverage. It includes 36 yearly cross-sectional regressions (year 1965 to 2000) and a total sample size of 5222 firm years. Each yearly regression includes dummies for industry, which is defined by the two-digit SIC code. Columns (1)-(3) contain results for human-capital proxies measured with $\alpha = 0.25$. Columns (4)-(6) contain results given $\alpha = 0.5$ and columns (7)-(9) contain results given $\alpha = 0.75$. T-statistics are in the parentheses. R^2 shown here is the averaged R^2 from the yearly regressions.

	the book value of long-term leverage								
	$\alpha = 0.25$			$\alpha = 0.5$			$\alpha = 0.75$		
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
q	−0.0062 (−0.6883)	−0.0027 (−0.2867)	−0.0074 (−0.808)	−0.0068 (−0.7458)	−0.0033 (−0.3487)	−0.0075 (−0.8217)	−0.0061 (−0.6714)	−0.0037 (−0.4006)	−0.0059 (−0.6519)
collateral value of assets	0.1449*** (6.9331)	0.1745*** (8.7201)	0.1003*** (4.3618)	0.1463*** (7.0549)	0.1727*** (8.6786)	0.0938*** (3.7865)	0.1556*** (7.3891)	0.1705*** (8.5997)	0.1238*** (5.4562)
R&D expenses	−0.6783*** (−4.1449)	−0.5255*** (−3.5697)	−0.6224*** (−3.3108)	−0.6311*** (−3.984)	−0.5091*** (−3.3555)	−0.572*** (−2.985)	−0.5687*** (−3.6259)	−0.5161*** (−3.2578)	−0.503*** (−3.0313)
profitability	−0.6004*** (−9.8422)	−0.5747*** (−8.6924)	−0.5746*** (−9.3973)	−0.599*** (−10.5058)	−0.5732*** (−9.2091)	−0.5696*** (−9.6794)	−0.5865*** (−10.9599)	−0.5662*** (−9.9117)	−0.5617*** (−10.6758)
non debt tax shield	3.4829* (1.8819)	3.8047** (1.9739)	3.347* (1.824)	3.5117* (1.8869)	3.9171** (1.9863)	3.5937* (1.9577)	4.0034** (2.0302)	4.2779** (2.0556)	4.1515** (2.0985)
sga expenses	0.0272 (0.9051)	0.0807** (2.1546)	0.0312 (1.0438)	0.0186 (0.6405)	0.0697** (2.2203)	0.0223 (0.7687)	0.002 (0.071)	0.0356 (1.309)	0.001 (0.0376)
firm size	0.0066*** (4.0323)	0.0083*** (4.8233)	0.0054*** (3.2704)	0.0068*** (4.212)	0.0085*** (5.0276)	0.0056*** (3.2749)	0.0079*** (4.9809)	0.009*** (5.3127)	0.0074*** (4.5354)
HCI1	−0.0033*** (−4.3733)			−0.0045*** (−6.593)			−0.0052*** (−7.1697)		
HCI2		−0.0305*** (−3.2268)			−0.0163*** (−4.3823)			−0.0084*** (−5.6231)	
HCI3			−0.0192*** (−7.3545)			−0.0167*** (−6.837)			−0.0108*** (−5.9102)
R^2	0.544	0.5399	0.5417	0.5426	0.5417	0.543	0.5436	0.5432	0.544

Table 5: Fama-MacBeth Regression

This table displays regression results from the Fama-MacBeth regression, with the dependent variable as the market value of long-term leverage. It includes 36 yearly cross-sectional regressions (year 1965 to 2000) and a total sample size of 5222 firm years. Each yearly regression includes dummies for industry, which is defined by the two-digit SIC code. Columns (1)-(3) contain results for human-capital proxies measured with $\alpha = 0.25$. Columns (4)-(6) contain results given $\alpha = 0.5$ and columns (7)-(9) contain results given $\alpha = 0.75$. T-statistics are in the parentheses. R^2 shown here is the averaged R^2 from the yearly regressions.

	the market value of long-term leverage								
	$\alpha = 0.25$			$\alpha = 0.5$			$\alpha = 0.75$		
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
q	−0.035*** (−4.463)	−0.0343*** (−4.37)	−0.0379*** (−4.8862)	−0.0355*** (−4.4631)	−0.0345*** (−4.3849)	−0.0378*** (−4.8486)	−0.0352*** (−4.4305)	−0.034*** (−4.3621)	−0.0359*** (−4.6112)
collateral value of assets	0.1337*** (8.2164)	0.1519*** (8.8853)	0.0894*** (4.9273)	0.1345*** (7.977)	0.1503*** (9.1929)	0.0904*** (4.8522)	0.1375*** (8.0184)	0.1495*** (9.3442)	0.1169*** (6.495)
R&D expenses	−0.4289*** (−3.9794)	−0.3524*** (−3.0048)	−0.3597*** (−3.088)	−0.4021*** (−3.6447)	−0.3307*** (−2.6443)	−0.3113*** (−2.6522)	−0.3752*** (−3.1698)	−0.3342*** (−2.657)	−0.2882** (−2.4356)
profitability	−0.5708*** (−10.1957)	−0.5451*** (−9.034)	−0.546*** (−10.5913)	−0.5738*** (−10.3379)	−0.5467*** (−9.309)	−0.5425*** (−10.8018)	−0.5707*** (−10.1819)	−0.5528*** (−9.4999)	−0.5477*** (−10.3633)
non debt tax shield	1.1649 (0.8034)	1.4963 (1.0007)	0.468 (0.3446)	1.2432 (0.8436)	1.5349 (1.0135)	0.9333 (0.6709)	1.4354 (0.9453)	1.6036 (1.0289)	1.5541 (1.0364)
sga expenses	−0.007 (−0.3289)	0.0416 (1.4678)	−0.0062 (−0.2784)	−0.0139 (−0.662)	0.0236 (0.9836)	−0.016 (−0.7615)	−0.025 (−1.2658)	−0.0023 (−0.1163)	−0.0314 (−1.5867)
firm size	0.0053*** (4.3148)	0.0067*** (5.0245)	0.0036*** (3.2163)	0.0055*** (4.5225)	0.0069*** (5.2851)	0.0043*** (3.8685)	0.0061*** (4.9658)	0.0069*** (5.234)	0.0059*** (5.1488)
HCI1	−0.0015** (−2.4274)			−0.0018*** (−2.9404)			−0.0023*** (−3.3412)		
HCI2		−0.0235*** (−3.2267)			−0.0111*** (−3.4027)			−0.0053*** (−3.2905)	
HCI3			−0.017*** (−7.5173)			−0.0128*** (−6.8002)			−0.0071*** (−4.2265)
R^2	0.582	0.579	0.5818	0.582	0.5811	0.5824	0.5824	0.582	0.5825

Table 6: Fama-MacBeth Regression

This table displays regression results from the Fama-MacBeth regression, with the dependent variable as the book value of total leverage. It includes 36 yearly cross-sectional regressions (year 1965 to 2000) and a total sample size of 5222 firm years. Each yearly regression includes dummies for industry, which is defined by the two-digit SIC code. Columns (1)-(3) contain results for human-capital proxies measured with $\alpha = 0.25$. Columns (4)-(6) contain results given $\alpha = 0.5$ and columns (7)-(9) contain results given $\alpha = 0.75$. T-statistics are in the parentheses. R^2 shown here is the averaged R^2 from the yearly regressions.

	the book value of total leverage								
	$\alpha = 0.25$			$\alpha = 0.5$			$\alpha = 0.75$		
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
q	−0.0062 (−0.7383)	−0.0032 (−0.3712)	−0.006 (−0.6754)	−0.0074 (−0.8733)	−0.0034 (−0.3951)	−0.0066 (−0.7409)	−0.0065 (−0.7673)	−0.0026 (−0.3094)	−0.0053 (−0.611)
collateral value of assets	0.1436*** (5.0128)	0.1674*** (6.1314)	0.102*** (3.453)	0.1456*** (4.8219)	0.1643*** (6.017)	0.0948*** (2.9566)	0.1493*** (4.8935)	0.1643*** (5.999)	0.1193*** (3.5826)
R&D expenses	−0.7501*** (−6.534)	−0.5625*** (−4.627)	−0.6743*** (−4.8849)	−0.6844*** (−6.7449)	−0.5624*** (−4.2501)	−0.5918*** (−4.6605)	−0.6265*** (−5.5313)	−0.5661*** (−4.278)	−0.5212*** (−4.8925)
profitability	−0.7269*** (−11.6425)	−0.6967*** (−10.5374)	−0.73*** (−11.2472)	−0.7162*** (−12.4478)	−0.6965*** (−10.8785)	−0.7169*** (−11.9771)	−0.7143*** (−12.5702)	−0.701*** (−11.3866)	−0.6943*** (−12.4076)
non debt tax shield	2.3344 (1.2619)	2.883 (1.4451)	2.182 (1.1772)	2.5642 (1.3138)	3.1846 (1.535)	2.4632 (1.3372)	3.024 (1.4983)	3.3658 (1.5929)	3.2445 (1.62)
sga expenses	0.0684** (2.1062)	0.1504*** (3.1524)	0.0775** (2.3159)	0.0551* (1.6597)	0.1193*** (2.9079)	0.0608* (1.8709)	0.0325 (1.0049)	0.0753** (2.2562)	0.0268 (0.7839)
firm size	0.0079*** (3.8384)	0.0101*** (4.8929)	0.0072*** (3.2637)	0.0084*** (4.1377)	0.0106*** (5.2306)	0.0074*** (3.5751)	0.0097*** (4.7718)	0.011*** (5.3522)	0.0096*** (4.7187)
HCI1	−0.003*** (−3.808)			−0.004*** (−4.4192)			−0.0055*** (−4.7596)		
HCI2		−0.0434*** (−3.6647)			−0.0202*** (−3.8219)			−0.0109*** (−4.2098)	
HCI3			−0.0187*** (−5.1227)			−0.0158*** (−6.5732)			−0.0103*** (−4.1689)
R^2	0.547	0.547	0.5492	0.5495	0.5494	0.5507	0.5514	0.5513	0.5523

Table 7: Fama-MacBeth Regression

This table displays regression results from the Fama-MacBeth regression, with the dependent variable as the market value of total leverage. It includes 36 yearly cross-sectional regressions (year 1965 to 2000) and a total sample size of 5222 firm years. Each yearly regression includes dummies for industry, which is defined by the two-digit SIC code. Columns (1)-(3) contain results for human-capital proxies measured with $\alpha = 0.25$. Columns (4)-(6) contain results given $\alpha = 0.5$ and columns (7)-(9) contain results given $\alpha = 0.75$. T-statistics are in the parentheses. R^2 shown here is the averaged R^2 from the yearly regressions.

	the market value of total leverage								
	$\alpha = 0.25$			$\alpha = 0.5$			$\alpha = 0.75$		
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
q	−0.0439***	−0.0439***	−0.046***	−0.045***	−0.0443***	−0.0465***	−0.0446***	−0.0428***	−0.0452***
	(−5.1566)	(−5.2491)	(−5.172)	(−5.2601)	(−5.3453)	(−5.3162)	(−5.2576)	(−5.2111)	(−5.3666)
collateral value of assets	0.1322***	0.1492***	0.0874***	0.1355***	0.1458***	0.0911***	0.134***	0.1474***	0.1172***
	(5.3543)	(6.7272)	(3.5052)	(4.8688)	(6.8523)	(3.2133)	(5.1158)	(6.7253)	(3.8514)
R&D expenses	−0.4858***	−0.3796***	−0.4282***	−0.4341***	−0.3702***	−0.3356***	−0.4155***	−0.3713***	−0.2911***
	(−5.4461)	(−3.9154)	(−4.2352)	(−5.0036)	(−3.4023)	(−3.878)	(−4.4016)	(−3.3615)	(−3.1514)
profitability	−0.7221***	−0.6897***	−0.7256***	−0.7089***	−0.6853***	−0.7048***	−0.7142***	−0.7004***	−0.6882***
	(−10.2709)	(−9.6358)	(−10.0282)	(−10.041)	(−9.6689)	(−10.5659)	(−10.2096)	(−9.7944)	(−9.9753)
non debt tax shield	−0.4958	0.0514	−1.3156	−0.1457	0.307	−0.7831	0.032	0.2564	0.1732
	(−0.3084)	(0.0301)	(−0.8507)	(−0.0871)	(0.1773)	(−0.5048)	(0.0186)	(0.1457)	(0.1036)
sga expenses	0.0189	0.0917***	0.0294	0.0068	0.0541	0.0108	−0.008	0.022	−0.0184
	(0.8082)	(2.6725)	(1.1469)	(0.2798)	(1.5327)	(0.4415)	(−0.3465)	(0.8771)	(−0.6886)
firm size	0.0055***	0.0073***	0.004**	0.0061***	0.0078***	0.0049***	0.0068***	0.0078***	0.0071***
	(3.3788)	(4.3759)	(2.334)	(3.6958)	(4.7562)	(3.1034)	(4.208)	(4.7516)	(4.2562)
HCI1	−0.0013*			−0.0013			−0.0023*		
	(−1.7436)			(−1.1644)			(−1.7907)		
HCI2		−0.0341***			−0.0137**			−0.007**	
		(−3.6131)			(−2.138)			(−2.4189)	
HCI3			−0.0182***			−0.0128***			−0.0063**
			(−6.595)			(−6.2432)			(−2.2059)
R^2	0.6033	0.6032	0.606	0.6059	0.6057	0.6069	0.6071	0.607	0.6077

Table 8: Modified t-statitics in Fama-MacBeth regression

The table displays the modified t-statistics from the Fama-MacBeth regression. It is based on 36 yearly cross-sectional regressions (year 1965 to 2000) and a total sample size of 5222 firm years. Each yearly regression includes dummies for industry, which is defined by the two-digit SIC code. The modified t-statistics are calculated as the averaged standardized coefficients divided by $\sqrt(n)$, here 36.

Human-capital proxy	$\alpha = 0.25$	$\alpha = 0.5$	$\alpha = 0.75$
Panel A: dependent variable: book value of long-term leverage			
HCI1	−6.2863	−7.5957	−9.1623
HCI2	−5.2022	−6.7244	−7.7842
HCI3	−9.0713	−10.7548	−10.9387
Panel B: dependent variable: market value of long-term leverage			
HCI1	−4.0836	−5.1589	−6.5048
HCI2	−4.074	−5.3979	−6.3138
HCI3	−9.7936	−10.4862	−9.823
Panel C: dependent variable: book value of total leverage			
HCI1	−6.0438	−7.7639	−9.7063
HCI2	−6.4814	−7.9647	−9.3526
HCI3	−7.9168	−10.126	−11.207
Panel D: dependent variable: market value of total leverage			
HCI1	−3.8906	−5.269	−6.8066
HCI2	−4.9985	−6.281	−7.447
HCI3	−9.012	−10.1095	−9.845

Table 9: Variation Explained by regressors

The table displays the variation of the leverage explained by important capital structure determinants. The variation explained is calculated as the regression coefficient from the Fama-MacBeth regression times the standard deviation of the regressor, divided by the standard deviation of the dependent variable. The human-capital intensity proxies are calculated given $\alpha = 0.5$.

	book long-term leverage	market long-term leverage
panel1		
HCI1	11.15%	10.31%
clatrl	8.09%	17.19%
profit	36.76%	81.38%
R&D	18.99%	27.96%
firm size	4.99%	9.32%
panel2		
HCI2	11.98%	18.86%
clatrl	9.55%	19.21%
profit	35.18%	77.54%
R&D	15.32%	23.00%
firm size	6.24%	11.70%
panel3		
HCI3	16.58%	29.36%
clatrl	5.19%	11.55%
profit	34.96%	76.94%
R&D	17.21%	21.65%
firm size	4.11%	7.29%

Table 10: Change of leverage with change of regressors

The table displays the change in leverage ratios with a change of one standard deviation of important capital structure determinants. The human-capital intensity proxies are calculated given $\alpha = 0.5$.

	book long-term leverage	market long-term leverage
panel1		
px1	3.23%	1.29%
clatrl	2.35%	2.16%
profit	10.66%	10.21%
R&D	5.51%	3.51%
firm size	1.45%	1.17%
panel2		
px2	3.48%	2.37%
clatrl	2.77%	2.41%
profit	10.20%	9.73%
R&D	4.44%	2.89%
firm size	1.81%	1.47%
panel3		
px3	4.81%	3.69%
clatrl	1.50%	1.45%
profit	10.14%	9.66%
R&D	4.99%	2.72%
firm size	1.19%	0.91%

Table 11: Alternative Regressions

This table displays results from the alternative regression methods, with the dependent variable as the book value of long-term leverage. It includes observations of 5290 from year 1962 to 2000. Human-capital proxies are measured with $\alpha = 0.5$. Columns (1)-(3) contain results from the pooled OLS with year and industry dummies. Industries are defined by the 2-digit SIC codes. Columns (4)-(6) contain results from the between-firm regressions. Columns (7)-(9) contain results from the within-firm regressions. Robust t-statistics are in the parentheses.

	the book value of long-term leverage and $\alpha = 0.5$								
	OLS			Between			Within		
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
q	0.1027***	0.1044***	0.1017***	0.0678*	0.0787**	0.0672*	0.109***	0.1155***	0.1167***
	(2.87)	(3.03)	(2.85)	(1.81)	(2.05)	(1.80)	(5.75)	(6.06)	(6.07)
collateral value of assets	0.2418***	0.2409***	0.1847***	0.3142***	0.3048***	0.2548***	0.1866***	0.1973***	0.136***
	(5.70)	(5.95)	(4.87)	(4.24)	(4.75)	(4.10)	(3.58)	(3.73)	(2.83)
R&D expenses	−0.4267*	−0.2315	−0.3107*	−0.2674*	−0.0956	−0.1655*	0.3965	0.4685	0.4442
	(-1.93)	(-1.47)	(-1.84)	(-1.92)	(-1.08)	(-1.70)	(0.92)	(1.24)	(1.18)
profitability	−0.4713***	−0.4159***	−0.4573***	−0.2988**	−0.2056*	−0.2702**	−0.291	−0.3498*	−0.3811*
	(-2.69)	(-2.80)	(-2.90)	(-2.32)	(-1.78)	(-2.16)	(-1.38)	(-1.84)	(-1.94)
non debt tax shield	−1.5899	−0.8959	−1.2208	1.5554	1.9777	2.207	0.3467	0.5054	0.8522
	(-1.36)	(-0.89)	(-1.12)	(0.78)	(1.01)	(1.13)	(0.51)	(0.81)	(1.36)
sga expenses	−0.027	0.0054	−0.0219	−0.0261	−0.0087	−0.0232	0.1688	0.0868*	0.0628
	(-0.99)	(0.20)	(-1.02)	(-1.60)	(-0.45)	(-1.42)	(1.47)	(1.74)	(1.36)
firm size	0.0073***	0.0102***	0.0067***	0.0009	0.004	0.0002	0.0418***	0.0556***	0.0543***
	(3.86)	(4.99)	(3.62)	(0.18)	(1.07)	(0.04)	(5.58)	(4.83)	(6.08)
HCI1	−0.003***			−0.0039**			−0.0015		
	(-3.39)			(-2.11)			(-1.41)		
HCI2		−0.0283***			−0.021**			−0.0191*	
		(-3.23)			(-2.28)			(-1.68)	
HCI3			−0.0148***			−0.0135***			−0.0167***
			(-4.11)			(-2.81)			(-3.25)
R^2	0.5920	0.6055	0.5939	0.4549	0.4856	0.4563	0.8556	0.8541	0.8547
observations	5249	5286	5287	843	857	858	5249	5286	5287

Table 12: Alternative Regressions

This table displays results from the alternative regression methods, with the dependent variable as the market value of long-term leverage. It includes observations of 5290 from year 1962 to 2000. Human-capital proxies are measured with $\alpha = 0.5$. Columns (1)-(3) contain results from the pooled OLS with year and industry dummies. Industries are defined by the 2-digit SIC codes. Columns (4)-(6) contain results from the between-firm regressions. Columns (7)-(9) contain results from the within-firm regressions. Robust t-statistics are in the parentheses.

	the market value of long-term leverage and $\alpha = 0.5$								
	OLS			Between			Within		
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
q	−0.0131***	−0.0129***	−0.0133***	−0.0096**	−0.0092**	−0.0097**	−0.0112***	−0.0102***	−0.0097***
	(-2.86)	(-2.85)	(-3.03)	(-2.39)	(-2.00)	(-2.48)	(-4.64)	(-4.46)	(-4.26)
collateral value of assets	0.1224***	0.1303***	0.0903***	0.2039***	0.2193***	0.1735***	0.0916***	0.0888***	0.0602***
	(7.61)	(8.12)	(5.55)	(5.75)	(6.10)	(4.82)	(4.25)	(4.29)	(2.73)
R&D expenses	−0.1839***	−0.128***	−0.1363***	−0.106**	−0.0573*	−0.0656**	−0.1389**	−0.1313**	−0.143**
	(-3.04)	(-2.68)	(-2.81)	(-2.50)	(-1.92)	(-1.96)	(-2.21)	(-2.08)	(-2.27)
profitability	−0.2419***	−0.2156***	−0.2432***	−0.1313***	−0.0974***	−0.1227***	−0.165***	−0.1825***	−0.2003***
	(-5.27)	(-5.20)	(-5.92)	(-3.91)	(-3.06)	(-3.85)	(-4.12)	(-4.83)	(-5.02)
non debt tax shield	−0.55	−0.278	−0.3566	0.0557	0.3595	0.4002	−0.017	0.0613	0.2215
	(-1.04)	(-0.54)	(-0.70)	(0.04)	(0.29)	(0.33)	(-0.04)	(0.16)	(0.57)
sga expenses	−0.0071	−0.0012	−0.0068	−0.0015	−0.0012	−0.0016	0.0226*	0.0117	0.0028
	(-0.85)	(-0.24)	(-1.20)	(-0.29)	(-0.29)	(-0.34)	(1.68)	(1.49)	(0.42)
firm size	0.0051***	0.0057***	0.0048***	0.0048**	0.0043**	0.0043**	0.0173***	0.0216***	0.0217***
	(5.73)	(6.36)	(5.47)	(2.36)	(2.13)	(2.17)	(6.63)	(6.16)	(8.04)
HCI1	−0.0016***			−0.0017**			−0.0005		
	(-4.27)			(-2.55)			(-1.63)		
HCI2		−0.0038			−0.0006			−0.0066*	
		(-1.18)			(-0.26)			(-1.89)	
HCI3			−0.0079***			−0.0063***			−0.0072***
			(-9.10)			(-5.17)			(-5.60)
R^2	0.3100	0.3047	0.3218	0.3394	0.3321	0.3537	0.7807	0.7804	0.7837
observations	5249	5286	5287	843	857	858	5249	5286	5287

Table 13: Firm Specificity: R&D expenses

This table displays Fama-MacBeth regression results for regression model 6.4, with the firm specificity measured by R&D expenses. It includes 36 yearly cross-sectional regressions (year 1965 to 2000) and a total sample size of 5222 firm years. Each yearly regression includes dummies for industry, which is defined by the two-digit SIC code. Columns (1)-(3) contain results with the dependent variable as the book value of long-term leverage. Columns (4)-(6) contain results with the dependent variable as the market value of long-term leverage. Human-capital intensity proxies are measured with $\alpha = 0.5$. T-statistics are in the parentheses. R^2 shown here is the averaged R^2 from the yearly regressions.

	book value of long-term leverage			market value of long-term leverage		
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
q	−0.009	−0.004	−0.0088	−0.0372***	−0.0349***	−0.0391***
	(−0.9985)	(−0.4196)	(−0.9373)	(−4.4331)	(−4.2484)	(−4.7269)
collateral value of assets	0.1213***	0.1722***	0.0797***	0.12***	0.1483***	0.0814***
	(3.7382)	(8.698)	(2.8611)	(6.6402)	(9.0139)	(4.2913)
profitability	−0.5986***	−0.5771***	−0.5692***	−0.5726***	−0.5524***	−0.5408***
	(−10.7485)	(−10.1521)	(−10.0927)	(−10.1485)	(−9.6419)	(−10.5113)
non debt tax shield	2.7413	3.6176*	3.0148*	0.3612	1.248	0.3077
	(1.5216)	(1.8189)	(1.6474)	(0.2544)	(0.8485)	(0.223)
sga expenses	−0.0047	0.073**	−0.0048	−0.0325	0.0215	−0.038
	(−0.1072)	(2.2182)	(−0.1408)	(−1.1794)	(0.8922)	(−1.4257)
firm size	0.0062***	0.0087***	0.0055***	0.0053***	0.0068***	0.0041***
	(4.4327)	(5.1842)	(3.5422)	(4.2839)	(5.2385)	(3.8147)
R&D expenses	−0.0431	−0.4491	−0.1118	0.0955	−0.3857*	0.1442
	(−0.1157)	(−1.2438)	(−0.4677)	(0.3739)	(−1.7272)	(0.6915)
HCI1	−0.0025**			−0.0004		
	(−2.2068)			(−0.3591)		
HCI1*R&D	−0.1057*			−0.0707**		
	(−1.8746)			(−2.3891)		
HCI2		−0.0163***			−0.0117***	
		(−3.016)			(−2.9791)	
HCI2*R&D		−0.0057			0.0367	
		(−0.0592)			(0.6353)	
HCI3			−0.0137***			−0.0103***
			(−5.5084)			(−3.597)
HCI3*R&D			−0.1575*			−0.1218**
			(−1.8884)			(−2.0571)
R^2	0.5584	0.551	0.5535	0.5904	0.586	0.5888

Table 14: Firm Specificity: Parrino's measure for industry homogeneity

This table displays Fama-MacBeth regression results for regression model 6.4, with the firm specificity measured by Parrino's industry correlation measure. It includes 36 yearly cross-sectional regressions (year 1965 to 2000) and a total sample size of 5222 firm years. Each yearly regression includes dummies for industry, which is defined by the two-digit SIC code. Columns (1)-(3) contain results with the dependent variable as the book value of long-term leverage. Columns (4)-(6) contain results with the dependent variable as the market value of long-term leverage. Human-capital intensity proxies are measured with $\alpha = 0.5$. T-statistics are in the parentheses. R^2 shown here is the averaged R^2 from the yearly regressions.

	book value of long-term leverage			market value of long-term leverage		
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
q	−0.0084* (−1.7369)	−0.0059 (−1.1605)	−0.0089* (−1.8817)	−0.0327*** (−5.4056)	−0.0317*** (−5.0205)	−0.0342*** (−5.8483)
collateral value of assets	0.1598*** (12.4315)	0.1777*** (14.6442)	0.12*** (8.7185)	0.1353*** (10.2011)	0.1416*** (12.3312)	0.0944*** (7.5153)
R&D expenses	−0.6418*** (−6.7743)	−0.5972*** (−5.8973)	−0.4955*** (−5.0577)	−0.4876*** (−5.5243)	−0.4516*** (−5.0154)	−0.333*** (−3.5355)
profitability	−0.5657*** (−10.6196)	−0.537*** (−9.1624)	−0.5465*** (−11.0064)	−0.5769*** (−9.721)	−0.5463*** (−8.8502)	−0.5654*** (−9.8355)
non debt tax shield	2.3014 (1.1588)	2.6467 (1.4019)	2.5395 (1.2862)	0.7784 (0.5283)	1.2109 (0.8413)	0.7722 (0.5395)
sga expenses	−0.0107 (−0.5048)	0.0136 (0.6837)	−0.0146 (−0.6956)	−0.0563*** (−3.3787)	−0.0289 (−1.5869)	−0.0654*** (−4.0386)
firm size	0.0027** (2.1856)	0.0048*** (3.918)	0.0024* (1.8096)	0.0013 (1.2024)	0.0028** (2.2708)	0.0007 (0.6611)
industry corr	−0.3992*** (−4.4326)	−0.5684*** (−6.4551)	−0.4885*** (−5.5749)	−0.3893*** (−5.2668)	−0.5002*** (−7.2272)	−0.4539*** (−7.3661)
HCI1	−0.0158*** (−5.1774)			−0.0164*** (−5.6147)		
HCI1* industry corr	0.0418*** (3.7462)			0.0536*** (5.0764)		
HCI2		−0.059*** (−6.2562)			−0.0566*** (−7.5657)	
HCI2* industry corr		0.2159*** (5.8409)			0.2053*** (8.1206)	
HCI3			−0.0459*** (−6.8365)			−0.045*** (−8.1136)
HCI3* industry corr			0.118*** (4.569)			0.1268*** (6.2903)
R^2	0.3397	0.3341	0.3396	0.4222	0.4173	0.4229

Figure 2: Payoff distribution under different capital structure

a. Under equity financing

	Continue	Liquidation
shareholder	$\theta + f(1) - W$	L
tech worker	W	0

b. Under debt financing

	Continue	Liquidation
shareholder	$\theta + f(1) - W - D$	0
tech worker	W	0

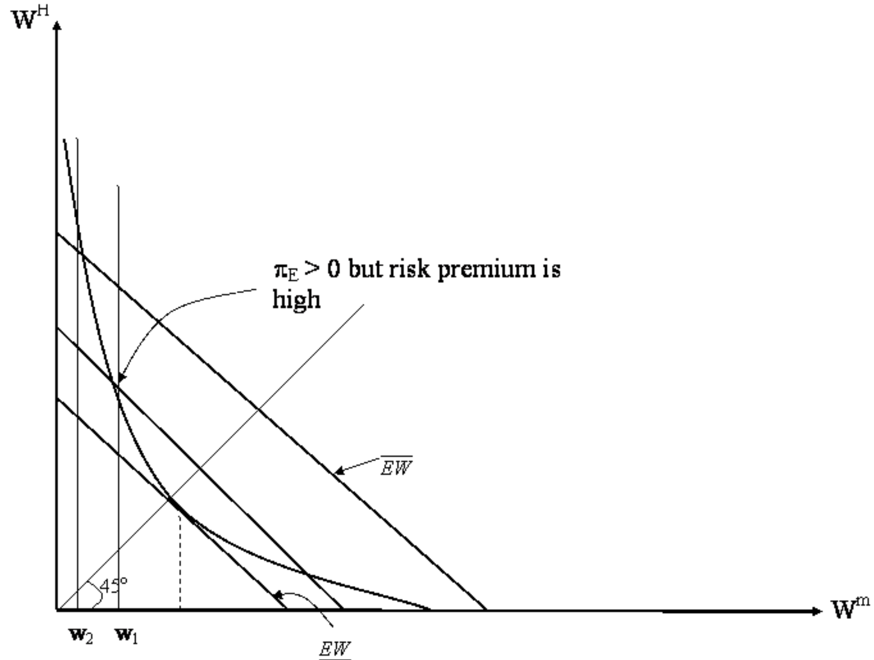

Figure 3: Renegotiation-proof compensation

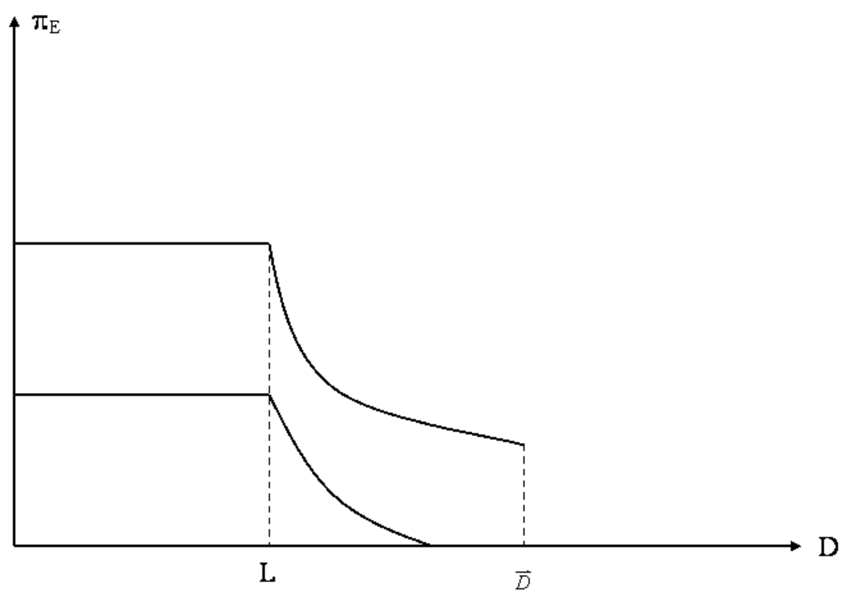

Figure 4: Shareholders' payoff as a function of debt

Figure 5: Payoff distribution when the entrepreneur holds stock options

a.

	Continue	Liquidation
shareholder +entrepreneur	$\theta + f(1) + g(e) - \nu(e) - W$	L
tech worker	W	0

b.

	Continue	Liquidation
shareholder	$(1-n)(\theta + f(1) + g(e) - W) + nK$	L
entrepreneur	$n(\theta + f(1) + g(e) - W - K) - \nu(e)$	L
tech worker	W	0