Asymmetric Information and the Disciplinary Role of Debt

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Abstract

We develop a model to show that debt financing can increase firm value by serving as a commitment device in the presence of information asymmetry. In the model, firms privately learn the true quality of their projects as time goes by, which can potentially cause adverse selection. To prevent this ex-post adverse selection, a firm's initial owner may prefer to issue debt before the project's quality is realized because this intentionally created debt will discourage equityholders from mimicking other high-quality firms later. The model predicts that firms in more profitable industries are more likely to issue debt through this mechanism.

Keywords: capital structure, information asymmetry, commitment device, debt overhang

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1 Introduction

Understanding how a firm's capital structure is determined is one of the most important topics in finance. In the literature, Modigliani and Miller (1958) first established the foundational work in this area by showing that capital structure is irrelevant to firm value under ideal market conditions. However, empirical evidence has since revealed a stark gap between such a theoretical prediction and the observed capital structure in practice. Consequently, researchers have explored various methods to reconcile the theoretical results with empirical observations.

Among many approaches, the trade-off theory aims to explain a firm's capital structure by examining the trade-offs between the tax benefits of debt and bankruptcy costs; see, for instance, Modigliani and Miller (1963) and Kraus and Litzenberger (1973). Jensen and Meckling (1976) and Myers (1977) analyze the conflicts of interest between equityholders and debtholders to understand the impact of debt financing on firm value. Ross (1977), Townsend (1979), and DeMarzo and Duffie (1999) show that debt financing can be optimal in the presence of information asymmetry between firms and investors, analyzing various aspects related to asymmetric information. Further, Grossman and Hart (1982) elucidate the fact that debt can be used as a commitment device when investors cannot enforce a firm's manager to make particular investment decisions due to unaligned interests. We will discuss more details about these papers later.

Our paper provides new insights to this field by highlighting the disciplinary role of debt financing in the presence of information asymmetry. Specifically, we show that debt issued at earlier dates can serve as a commitment device in situations where a firm's initial owner cannot commit not to mimic high-quality firms seeking to finance new projects at a later date, especially when she discovers her own firm's investment opportunities would not be profitable. In other words, a firm's initial owner can intentionally cause the so-called debt-overhang problem at a later date so that she would lose an incentive to mimic high-quality firms aiming to raise capital for a new investment project at that date. This strategy will effectively work for the initial owner of the firm from the ex-ante perspective because the intentionally created debt-overhang problem will be detrimental only for less productive firms, provided that the amount of debt has been cautiously chosen beforehand.

To present this idea more rigorously, we develop a two-period model. We consider a firm that has investment opportunities in two projects. The investment opportunity for the first project arrives today, while the second project can be taken on only at date 1. The cash flows of the two projects are generated at date 2. The firm can raise capital for the first project by issuing equity and debt, but the firm can issue only equity to finance the second project due to some covenants that will be enforced by the firm's initial investors. As such, the debt-overhang problem is expected to arise at date 1 if the firm chooses to issue debt today. The quality of the projects or the firm itself is realized at the beginning of date 1. But the true quality of the firm is only known to the firm's equityholders. Thus, the asymmetric information problem arises when the firm's equityholders attempts to raise additional capital for the second project. Assuming the second project has a negative net present value under a low-quality firm's management, a separating equilibrium in which only high-quality firms invest in the second project would be the socially optimal outcome. Nonetheless, the firm's initial owner and other initial equity investors cannot commit not to mimic high-quality firms trying to finance the second project, after realizing their own firm's investment projects would be unprofitable. In this situation, to avoid this second-best outcome, the firm's initial owner can use debt financing as a commitment device because the intentionally created debt burden will more adversely affect the equityholders of low-quality firms than those of high-quality firms. Using this financing strategy, the firm's initial owner can attain a higher firm value ex ante, compared to the case where the firm issues only equity.

The mechanism introduced in this paper is different from the mechanisms considered in the above-mentioned papers. First, Ross (1977) analyzes the signaling role of debt finance in the presence of bankruptcy costs. But our paper does not consider the signaling role of debt financing. More specifically, in our model, a firm's initial capital structure is determined before the true quality of that firm is realized. Townsend (1979) shows that debt financing can be optimal when a firm's outputs can be observed by investors only at some costs, leading to a moral hazard problem. However, our model does not consider such a moral hazard problem with truthful reporting. DeMarzo and Duffie (1999) investigate how a firm can design an optimal security by utilizing the informational insensitivity of debt to overcome illiquidity caused by information asymmetry. In our paper, the advantage of debt financing does not come from the informational insensitivity of debt. Instead, our paper highlights the role of debt as a commitment device in the situation where the asymmetric information problem is entangled with the debt-overhang problem. Moreover, the mechanism through which debt serves as a commitment device in our model is different from that in Grossman and Hart (1982). Grossman and Hart (1982) consider a setup in which the manager and investors of a firm may have different incentives after funds are raised. In this case, a firm's manager can issue debt to deliberately create the bankruptcy risk because such a bankruptcy threat will motivate the manager to make investment decisions that are more favorable to the firm's investors. In our paper, we do not consider such a moral hazard problem. Instead, we consider the investment problem with information asymmetry, in which debt serves as a disciplinary device by dampening the incentives of a firm's initial owner and equityholders to mimic high-quality firms ex post.

Our model predicts that firms in a more profitable industry will issue more debt. Specifically, in our model, a pooling equilibrium in which both high-quality and low-quality firms invest is more likely to emerge when the average value of firms is relatively higher. Thus, to prevent this outcome, firms choose to issue more debt ex ante, which can serve as a self-disciplinary tool as mentioned above. This prediction is basically consistent with not only the trade-off theory but also the information-based theory suggested by Ross (1977), Heinkel (1982), and Harris and Raviv (1991). But the empirical evidence regarding the relationship between profitability and financial leverage is mixed. For instance, Titman and Wessels (1988), Rajan and Zingales (1995), Fama and French (2002), and Frank and Goyal (2008) find a negative cross-sectional relationship between profitability and financial leverage. However, Harris and Raviv (1991) document that announcements of an increase in leverage have been followed by a rise in share prices on average. Masulis (1980) also find that an increase in leverage is accompanied with increases in stock prices and firm values, when compared to the cases where repurchases of common stock are financed with cash. See also Klein et al. (2002) and Graham and Leary (2011) for an excellent survey on this topic.

Given the challenges in examining the relationship between profitability and leverage, we may need an alternative method to test our model predictions. One suggestion is that we can examine whether stock prices or firm values exhibit larger gaps across different firms in subsequent periods after firms issued debt. This prediction is worth testing because our model implies that a separating equilibrium is more likely to arise when firms issue more debt ex ante, while a pooling equilibrium or the no-investment equilibrium, in which no firms invest at the expansion stage, is more likely to emerge in other cases.

The paper is organized as follows. In Section 2, we develop the model. In Section 3, we analyze the model and discuss the model implications. In Section 4, we discuss the empirical implications of the model. In Section 5, we provide concluding remarks.

2 Model

We consider a firm with investment opportunities in two projects, say, projects A and B. There are three dates, indexed by $t \in \{0, 1, 2\}$. Project A requires investments of I_A at date 0 and project B requires investments of I_B at date 1. We interpret project A as an investment opportunity at an early stage and project B as an investment opportunity at an expansion stage. For simplicity, we assume that both projects produce cash flows only at date 2. We can certainly assume that project A also produces cash flows at date 1, but such an assumption would only complicate our analysis without providing additional implications in our context.

The firm's current equityholders control the investment decisions at both dates 0 and 1. We assume that the initial owner of the firm has no cash and so, the firm has to raise capital from outside investors if the firm aims to invest in project A. We also assume that the firm cannot raise capital for investment in project B in advance, that is, at date 0. To justify this assumption, we can argue that firms face substantial amounts of cash-carrying costs and therefore, they do not choose to raise any capital for investment in project B in advance. The cash-carrying costs can be interpreted as the costs associated with moral hazard problems or tax distortions. To provide more general results, we can explicitly introduce cash-carrying costs to our model; but as the main results of our model occur when the cash-carrying costs are large and the opposite case would not generate interesting results, we do not consider such a more general setup.

The firm can issue both equity and debt at date 0. But, at date 1, the firm is restricted to issuing only equity because the firm's initial investors, who aim to protect their stakes against potential significant dilution caused by newly issued debt, will enforce restrictive covenants. The assumption that the additional investment should be funded from only equity investors can potentially cause the so-called debt-overhang problem at date 1, because the benefits of the new investment will be first accrued to the firm's debtholders, as in Myers (1977). Both equity and debt issuance markets are competitive. All market participants are risk neutral and discount future cash flows at a constant rate normalized to 0.

The performance of the projects depends on the firm's type, which can be either high (H) or low (L). The type is unknown at date 0, but it is realized at the beginning of date 1. The probability that a given firm will be of high type is $\pi \in (0, 1)$.

To describe the type-dependent performance of a firm, for a moment, suppose that there is no investment opportunity in project B. Then, for each type $k \in \{H, L\}$, project A alone under a k-type firm's management will produce cash flows of

$$\begin{cases} C & \text{with probability } p_k \\ 0 & \text{with probability } 1 - p_k \end{cases}$$

at date 2, where $p_L < p_H \leq 1$. That is, the success probability of project A is higher when the project is run by a high-type firm. We also assume that

$$[\pi p_H + (1 - \pi) p_L] C > I_A, \tag{1}$$

which means that project A has a positive ex-ante net present value (NPV). As such, investors always choose to fund project A at date 0.

Project B increases the success probability of project A. Specifically, for each type $k \in \{H, L\}$, if a k-type firm invests in project B, then the probability that project A will produce cash flows of C increases from p_k to $p_k + \Delta_k$, where

$$\Delta_L < \Delta_H \quad \text{and} \quad p_H + \Delta_H \leq 1.$$

Here, we can certainly consider another setup in which project B produces additional cash flows at date 2 rather than increasing the success probability of project A. But such a setup will only complicate the analysis due to the possibility of debt financing without changing the main results of the paper.

The NPV of project B is positive only for a high-type firm; that is, we assume that

$$\Delta_L C < I_B < \Delta_H C. \tag{2}$$

Accordingly, investing in project B would not be socially optimal if the firm turns out to be of low type. But a low-type firm may have incentives to invest in project B in our model because of information asymmetry between the firm's insiders and outside investors, to be described below.

As mentioned above, a firm's type is realized at the beginning of date 1. But we assume that only the firm's current equityholders can observe its realized type, while outside investors cannot. After observing the firm's type, the equityholders decide whether to invest in project B by issuing additional equity shares to new investors. Here, we have implicitly assumed that the firm's current equityholders do not have any additional capital to fund project B.

The timeline of the model is as follows. At date 0, the firm's initial owner makes the investment and financing decisions to maximize the present value of her initial equity ownership, that is, the date-0 firm value. At the beginning of date 1, the firm's type is realized. After privately observing the firm's type, the firm's current equityholders decide whether to invest in project B by issuing additional equity shares. At date 2, the firm produces cash flows.

3 Model Analysis and Implications

In this section, we characterize an equilibrium of the model and examine the optimal capital structure of a firm. To begin, recall that since project A has a positive NPV at date 0, each firm chooses to invest in project A by issuing equity and debt. Let $F \geq 0$ denote the face value of debt. Here, depending on situations, the firm may want to raise capital more than what is needed for the investment in project A. Specifically, we will later see that such a case indeed arises, especially when the firm wants to take a substantial amount of debt. Nonetheless, as we have assumed the cash-carrying costs are sufficiently large, the firm's initial owner has to consume the residual capital raised at date 0. Now, to determine the optimal level of debt at date 0, we first analyze the date-1 problem of the firm.

3.1 Date-1 Problem

At date 1, the firm's current equityholders make the investment decision for project B. At this stage, one of the following three cases can occur: (i) only a high-type firm invests, (ii) both high-type and low-type firms invest, and (iii) no firms invest in project B. We call the first type of equilibrium the separating equilibrium, the second type of equilibrium the pooling equilibrium, and the third type of equilibrium the no-investment equilibrium. For clarification, note that we need not consider the case where only a low-type firm invests because project B under a low-type firm's management has a negative NPV.

Separating Equilibrium: Consider the first case where only a high-type firm invests in project B. Specifically, in this case, suppose the equityholders of a high-type firm sell a fraction β of their equity shares to new investors to finance project B, while a low-type firm does not invest in project B. For such a separating equilibrium to arise, the following conditions must hold:

$$\beta(p_H + \Delta_H)(C - F) = I_B, \tag{3}$$

$$(1 - \beta)(p_H + \Delta_H)(C - F) \geq p_H(C - F), \tag{4}$$

$$(1 - \beta)(p_L + \Delta_L)(C - F) \leq p_L(C - F), \tag{5}$$

for some $\beta \in (0, 1]$. Condition (3) is the participation constraint, which means that the present value of the profits to outside investors must justify the amount of capital that is required to be raised for project B. For clarification, we without loss of generality need not consider the case where a high-type firm raises capital more than necessary at date 1 because doing so only increases the incentives of the equityholders of a low-type firm to mimic the financing policy of a high-type firm, without changing the present value of the profits to the equityholders of a high-type firm.

The condition in (4) is the incentive compatibility (IC) condition for the equityholders of a high-type firm. That is, this condition means that the equityholders of high-type firm indeed prefer to invest in project B by issuing new equity. The term on the left-hand side indicates the present value of the profits that the current equityholders can earn by investing in project B. The term on the right-hand side is the present value of the profits that will be earned at date 2 if project B is not undertaken at date 1.

The condition in (5) is the incentive compatibility condition for the equityholders of a low-type firm. That is, this condition indicates that the equityholders of a low-type firm indeed prefer not to invest in project B. The terms on the left-hand side denote the present value of the profits that the current equityholders can earn by mimicking the financing policy of a high-type firm. The term on the right-hand side indicates the present value of the profits that the current equityholders will earn without investing in project B.

In addition, as off-equilibrium beliefs, we assume that if the equityholders of any firm try to sell a different fraction of their equity ownership from the fraction satisfying the above three conditions, if any, outside investors would believe that firm to be a low-type firm. Then, because project B under a low-type firm's management has a negative NPV, no firms will have strong incentives to deviate from their equilibrium behaviors.

Now, analyzing the conditions from (3) to (5), we see that a separating equilibrium exists if

$$I_B \leq \Delta_H(C-F) \quad \text{and} \quad \Delta_L(C-F) \leq \frac{p_L+\Delta_L}{p_H+\Delta_H} \times I_B. \tag{6}$$

Intuitively, the first condition means that the amount of debt issued at date 0 should not be too large so that the equityholders of a high-type firm still have incentives to invest in project B. In other words, the debt-overhang problem that will be faced by the equityholders of a high-type firm at date 1 should not be too severe. Meanwhile, the second condition above means that the amount of debt should be at least higher than some level to prevent the equityholders of a low-type firm from mimicking the financing strategy of a high-type firm. Here, we have used the fact that $\frac{p_L+\Delta_L}{p_H+\Delta_H} \times I_B$ is the effective investment costs incurred to a low-type firm that tries to mimic a high-type firm. In other words, to eliminate the incentives of the equityholders of a low-type firm to mimic the behavior of a high-type firm, the debt-overhang problem faced by a low-type firm should be severe enough. Consequently, the separating equilibrium arises at date 1 if a firm issues an appropriate level of debt so that the equityholders of a low-type firm would not have any incentives to mimic a high-type firm, while the equityholders of a high-type firm would still prefer to invest in project B.

From condition (6), note that the separating equilibrium can potentially arise only when $\frac{1}{\Delta_H} < \frac{p_L+\Delta_L}{(p_H+\Delta_H)\Delta_L}$, which is reduced to $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$. In Section 3.2, we will discuss in more detail under what conditions, a firm's initial owner can indeed attain the first-best firm value by inducing the separating equilibrium through debt financing.

Pooling Equilibrium: We now consider the second case where both high-type and low-type firms invest in project B. In fact, in our model, a pooling equilibrium in which the equityholders of low-type firms use a mixed strategy arises. Specifically, to examine such an equilibrium, imagine that each high-type firm invests with certainty and each low-type firm invests with a probability $\theta \in (0, 1]$. Here, a pooling equilibrium with $\theta \in (0, 1)$ can be particularly called a hybrid equilibrium, but we would not use this terminology. To pin down a pooling equilibrium, we postulate that the equityholders of any type of a firm sell the same fraction of their equity ownership, denoted by β, in the case where they indeed have decided to invest in project B. For this type of an equilibrium to arise, the following conditions must hold:

$$\beta \cdot \frac{\pi(p_H + \Delta_H) + (1-\pi)\theta(p_L + \Delta)}{\pi + (1-\pi)\theta} \cdot (C - F) = I_B, \tag{7}$$

$$(1-\beta)(p_H + \Delta_H)(C - F) \geq p_H(C - F), \tag{8}$$

$$\begin{cases} (1-\beta)(p_L + \Delta_L)(C - F) = p_L(C - F), & \text{if } \theta \in (0, 1) \\ (1-\beta)(p_L + \Delta_L)(C - F) \geq p_L(C - F), & \text{if } \theta = 1 \end{cases} \tag{9}$$

for some $\beta \in (0, 1]$ and $\theta \in (0, 1]$. Similar to the above, condition (7) is the participation constraint, which means that the present value of the profits to outside investors must justify the amount of investment outlay required for project B, where we have used the fact that investors now cannot distinguish between high-type firms and low-type firms from their financing decisions. Again, we need not consider the case where a firm raises capital more than necessary. Specifically, if the pooling equilibrium, in which the term on the left side in (7) is larger than the term on the right side, the equityholders of high-type firms would prefer to sell a less fraction of their equity ownership, while the equityholders of low-type firms would not prefer to do so. Thus, utilizing the intuitive criterion introduced by Cho and Kreps (1987), we can focus on the case where each firm raises only the required amount of capital to invest in project B.

Condition (8) is the incentive compatibility condition, which means that the equityholders of a high-type firm prefer to invest in project B. Condition (9) is the incentive compatibility condition for the equityholders of a low-type firm. More specifically, the first line in (9) indicates the case where the equityholders of a low-type firm are indifferent between investing and not investing in project B, whereas the second line indicates the case where the equityholders of a low-type firm prefer to invest in project B. As such, in the first case, each low-type firm invests with a probability $\theta \in (0, 1)$, while in the second case, each low-type firm invests with certainty, leading to a pooling equilibrium with pure strategies. Regarding off-equilibrium beliefs, we again assume that any firms taking an action that is not supposed to be observed in equilibrium would be believed to be low-type firms.

To find a pair of β and θ satisfying the conditions from (7) to (9), we consider two cases: $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$ or $\frac{\Delta_L}{p_L} > \frac{\Delta_H}{p_H}$. Throughout, we do not pay much attention to knife-edge cases for convenience unless otherwise emphasized. When $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$, the IC constraint for low-type firms, that is, condition (9), implies the IC constraint for high-type firms, that is, condition (8). Thus, examining the IC constraint only for the low-type firms, we see that if

$$\frac{(p_L + \Delta_L)I_B}{(p_H + \Delta_H)\Delta_L} \leq C - F \leq \frac{(p_L + \Delta_L)I_B}{[\pi(p_H + \Delta_H) + (1 - \pi)(p_L + \Delta_L)]\Delta_L}, \tag{10}$$

then a pooling equilibrium with $\theta \in (0, 1)$ arises, whereas if

$$\frac{(p_L + \Delta_L)I_B}{[\pi(p_H + \Delta_H) + (1 - \pi)(p_L + \Delta_L)]\Delta_L} \leq C - F, \tag{11}$$

then a pooling equilibrium with $\theta = 1$ arises. Specifically, condition (11) means that the benefits of the new investment to the equityholders of a low-type firm are higher than the effective investment costs incurred to those equityholders. Hence, in this case, each low-type firm invests in project B with probability $\theta = 1$. When condition (10) holds, the benefits of the new investment to the equityholders of a low-type firm are relatively smaller. Thus, in this case, a different type of a pooling equilibrium arises, in which each low-type firm invests in project B with a probability less than 1.

Next, we consider the case of $\frac{\Delta_L}{p_L} > \frac{\Delta_H}{p_H}$. In this case, the IC constraint for high-type firms and the IC constraint for low-type firms with $\theta \in (0, 1)$ cannot hold at the same time. Also, the IC constraint for high-type firms implies the IC constraint for low-type firms with $\theta = 1$. Thus, in the case of $\frac{\Delta_L}{p_L} > \frac{\Delta_H}{p_H}$, by examining only the IC constraint for high-type firms, we see that a pooling equilibrium with $\theta = 1$ arises if

$$\frac{(p_H + \Delta_H)I_B}{[\pi(p_H + \Delta_H) + (1 - \pi)(p_L + \Delta_L)]\Delta_H} \leq C - F. \tag{12}$$

Specifically, this condition means that the benefits of the new investment to the equityholders of high-type firms prefer to invest in project. As mentioned above, this condition actually implies that the equityholders of low-type firms also prefer to invest.

For clarification, we have not considered the case where each high-type firm invests with a probability $\theta \in (0, 1]$ and each low-type firm invests with certainty. But we can show that this type of a pooling equilibrium never arises in our model because when this type of an equilibrium is expected to emerge, the firm's initial owner can actually induce another type of an equilibrium in which the ex-ante firm value is larger, compared to the original case. We omit the details.

No-Investment Equilibrium: Lastly, we consider the third type of equilibrium in which no firms invest in project B. To pin down this type of equilibrium, we first need to specify off-equilibrium beliefs regarding firms seeking to invest in project B. Specifically, we assume that outside investors believe any firm trying to raise capital for project B to be a low-type firm. Under this off-equilibrium belief, we consider two cases: $(p_L + \Delta_L)(C - F) < I_B$ or $(p_L + \Delta_L)(C - F) > I_B$. In the first case, the no-investment equilibrium trivially arises because in this case firms cannot even raise the required amount of capital for project B from outside investors. So, we now assume $(p_L + \Delta_L)(C - F) > I_B$. In this case, the no-investment equilibrium arises if for any $\beta \in (0, 1]$ satisfying

$$\beta(p_L + \Delta_L)(C - F) \geq I_B, \tag{13}$$

the following condition holds:

$$\beta(p_L + \Delta_L)(C - F) - I_B + (1 - \beta)(p_H + \Delta_H)(C - F) \leq p_H(C - F). \tag{14}$$

As before, condition (13) is the participation constraint for outside investors. Condition (14) is the incentive compatibility condition for high-type firms, which means that the equityholders of a high-type firm prefer not to invest in project B. For clarification, we have omitted stating the incentive compatibility condition for low-type firms, because that condition trivially holds when project B under a low-type firm's management has a negative NPV and any firm seeking to finance project B would be believed to be a low-type firm.

In addition, as in the other types of equilibrium, we can focus on the case where condition (13) holds with equality, but the underlying reason is slightly different from the reasons explained before. Specifically, under the above-mentioned off-equilibrium beliefs, if the equityholders of a high-type firm were to finance project B, they would prefer to sell the least possible fraction of their equity ownership to new investors. Hence, if there is one particular β, denoted by β^*_{no}, satisfying the two conditions in (13) and (14) with equality for condition (13), those two conditions will still hold with any other β larger than β^*_{no}. Therefore, we can simply focus on the case where condition (13) holds with equality.

Given this observation, we see that the no-investment equilibrium arises if

$$\Delta_H(C - F) \leq \frac{p_H + \Delta_H}{p_L + \Delta_L} \times I_B. \tag{15}$$

That is, the term on the left side is the benefits of the new investment to the equityholders of a high-type firm, while the term on the right side is the effective investment costs that would be incurred to a high-type firm under the off-equilibrium beliefs. Thus, the above condition means that the equityholders of a high-type firm prefers to forgo the investment opportunity in project B. Further, note that condition (15) includes the case of $(p_L + \Delta_L)(C - F) < I_B$, in

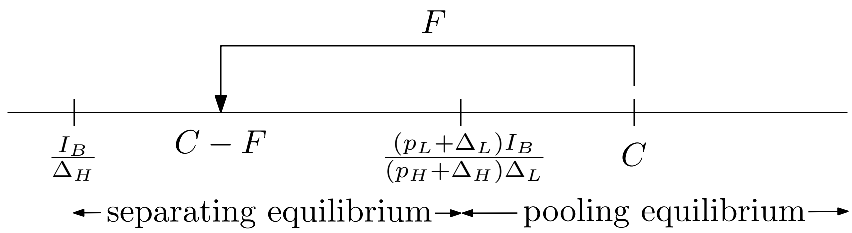

Figure 1: This figure depicts the case of $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$. In this case, if $C \leq \frac{(p_L+\Delta_L)I_B}{(p_H+\Delta_H)\Delta_L}$, a firm's initial owner can attain the first-best firm value without having to issue any debt. But in the other case, she can attain the first-best firm value by issuing a positive amount of debt.

which firms cannot even raise the required amount of capital for project B. So, we can simply say that the no-investment equilibrium arises if condition (15) holds, without considering the case of $(p_L + \Delta_L)(C - F) < I_B$ and its opposite case separately.

3.2 Date-0 Problem and Capital Structure

We now consider the date-0 problem of the firm's initial owner. For the date-0 problem, we consider the following two cases: (i) $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$ and (ii) $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$. Recall that different types of equilibrium can arise in our model, mainly depending on whether the first or the second condition holds.

Case (i): When $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$, we have seen that the firm's initial owner can attain the maximum possible firm value, that is, the first-best firm value, by issuing a mix of equity and debt. More specifically, due to the conditions in (6), to achieve this goal, the firm's initial owner has to set the face value of debt as follows:

$$C - \frac{(p_L + \Delta_L)I_B}{(p_H + \Delta_H)\Delta_L} \leq F \leq C - \frac{I_B}{\Delta_H}. \tag{16}$$

Here, we can easily check that $\frac{(p_L+\Delta_L)I_B}{(p_H+\Delta_H)\Delta_L} > \frac{I_B}{\Delta_H}$, using the condition $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$. Also, since we have already imposed the condition $\Delta_H C > I_B$, we can always find a face value $F \geq 0$ that satisfies condition (16).

The above result provides new insights into the role of capital structure in determining firm value. To be more specific, let us consider the case of $\frac{(p_L+\Delta_L)I_B}{(p_H+\Delta_H)\Delta_L} < C$. In this case, conditions (10) and (11) imply that a pooling equilibrium with either mixed strategies or pure strategies arises if the firm does not issue any amount of debt at date 0. Hence, to attain the first-best firm value, the firm has to issue a positive amount of debt with a face value satisfying condition (16), because doing so, the firm can induce the separating equilibrium ex post. Figure 1 illustrates this statement clearly. Here, as mentioned earlier, a situation where the amount of capital raised at date 0 is larger than the required amount of capital for the investment in project B can arise. That is, this outcome occurs when the future cash flow C is so large that the firm has to take a large amount of debt at date 0 to induce the separating equilibrium at date 1.

Intuitively, the above result occurs because if a firm issues a moderate amount of debt at date 0, then after the firm's type is realized, such a pre-existing debt burden eliminates the incentives of the equityholders of low-type firms to mimic high-type firms, without substantially hurting the incentives of the equityholders of a high-type firm to take on the positive-NPV project. In other words, the firm's initial owner can use debt financing as a commitment device because the debt-overhang problem that will be caused by the debt issued today will discourage herself from mimicking high-type firms when her own firm turns out to be a low-type firm.

However, when $C \leq \frac{(p_L+\Delta_L)I_B}{(p_H+\Delta_H)\Delta_L}$, condition (16) implies that the firm's initial owner can attain the first-best firm value without having to issue any amount of debt. That is, in this case, the equityholders of low-type firms value the new investment opportunity quite low even in the absence of any debt burden; therefore, any firm's initial owner does not need to issue any amount of debt to commit not to mimic high-type firms after her own firm's type is realized.

For clarification, due to condition (15), note that the no-investment equilibrium may also arise at date 1 in our model, especially when $\frac{I_B}{\Delta_H} < C - F < \frac{(p_H+\Delta_H)I_B}{(p_L+\Delta_L)\Delta_H}$. However, in the case of $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$, in which the separating equilibrium arises, we can rule out the no-investment equilibrium, using the intuitive criterion introduced by Cho and Kreps (1987). Specifically, let β^*_{sep} denote the fraction of equity ownership that is sold to new investors at date 1 in the separating equilibrium. Then, we see that the no-investment equilibrium cannot meet the intuitive criterion because if such an equilibrium hypothetically arises, the equityholders of high-type firms would strongly prefer to sell a fraction β^*_{sep} of their equity ownership, while

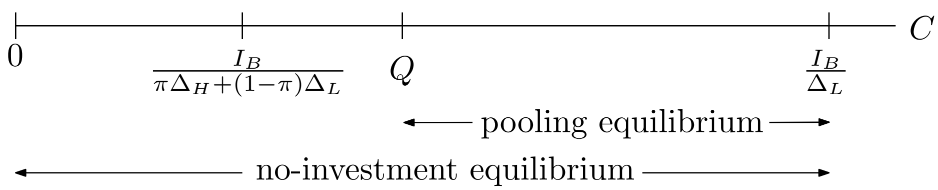

Figure 2: This figure illustrates the case of $\frac{\Delta_H}{p_H} < \frac{\Delta_L}{p_L}$. In this case, a firm's initial owner does not have any strong incentives to issue debt at date 0.

the equityholders of low-type firms would not, if such a deviating firm would believed to be a high-type firm. In this regard, we can exclude the no-investment equilibrium.

As a numerical example, let us consider the case of

$$p_H = 0.5,\ \Delta_H = 0.4,\ p_L = 0.2,\ \Delta_L = 0.4,\ \pi = 0.5,\ I_A = 0.8,\ I_B = 1,$$

which satisfies the condition $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$. So, in this case, the firm's initial owner can attain the first-best firm value by (i) issuing only equity if $C \in [2.50, 3.33]$ and (ii) by issuing a mix of equity and debt if $C \in (3.33, 5)$. For clarification, condition (1) also holds under these parameter values.

Case (ii): When $\frac{\Delta_L}{p_L} > \frac{\Delta_H}{p_H}$, we will see that both the pooling and the no-investment equilibrium can arise. First, in this case, the no-investment equilibrium can always arise because

$$C - F < \frac{I_B}{\Delta_L} < \frac{p_H + \Delta_H}{p_L + \Delta_L} \times \frac{I_B}{\Delta_H},$$

where the first inequality comes from condition (2), which says project B of a low-type firm has a negative NPV, and the second inequality comes from the condition $\frac{\Delta_L}{p_L} > \frac{\Delta_H}{p_H}$. Second, recall that in the case of $\frac{\Delta_L}{p_L} > \frac{\Delta_H}{p_H}$, the pooling equilibrium in which both high-type and low-type firms invest with certainty arises if

$$Q := \frac{(p_H + \Delta_H)I_B}{\sum_{k\in\{H,L\}} \pi_k(p_k + \Delta_k)\Delta_H} \leq C - F, \tag{17}$$

where $\pi_H = \pi$ and $\pi_L = 1 - \pi$.

Now, let us examine how a firm's initial capital structure is determined. To this aim, we can focus on the case where

$$Q < C < \frac{I_B}{\Delta_L}, \tag{18}$$

because when this condition does not hold, only the no-investment equilibrium arises and in that case, a firm's initial capital structure would be irrelevant to the firm value. As such, we focus on the case of (18). Now, we can easily show that condition (18) implies that

$$I_B < (\pi\Delta_H + (1-\pi)\Delta_L)C, \tag{19}$$

using the condition $\frac{\Delta_H}{p_H} < \frac{\Delta_L}{p_L}$. We omit presenting the proof. The result described in (19) means that the pooling equilibrium is preferred to the no-investment equilibrium. But then, note that (17) implies that a firm's initial owner would have incentives to issue debt only when she aims to induce the no-investment equilibrium at date 1. Thus, when condition (18) holds, the pooling equilibrium is preferred, a firm's initial owner does not have any strong incentives to issue debt regardless of which equilibrium selection rule is applied, as in the case where condition (18) does not hold. Figure 2 depicts the above arguments.

We summarize the key results of this section below.

Proposition 3.1. Suppose $\frac{\Delta_L}{p_L} < \frac{\Delta_H}{p_H}$. Then, if $C \leq \frac{(p_L+\Delta_L)I_B}{(p_H+\Delta_H)\Delta_L}$, then a firm's initial owner can attain the first-best firm value without having to issue any amount of debt at date 0. But if $\frac{(p_L+\Delta_L)I_B}{(p_H+\Delta_H)\Delta_L} < C$, the firm can attain the first-best firm value by issuing debt with a face value satisfying condition (16). On the other hand, when $\frac{\Delta_H}{p_H} < \frac{\Delta_L}{p_L}$, a firm's initial owner does not have any strong incentives to issue debt at date 0. In this case, when $Q < C < \frac{I_B}{\Delta_L}$, either the pooling equilibrium or the no-investment equilibrium can arise, depending on the equilibrium selection rule. When the condition $Q < C < \frac{I_B}{\Delta_L}$ does not hold, only the no-investment equilibrium arises.

4 Further Discussions

In this section, we discuss some methods that can be potentially used to test our model predictions. First, our model predicts a positive relationship between a firm's future profitability and its leverage level. Specifically, as mentioned before, in our model, if a firm's manager expects that a pooling equilibrium, which is the second-best outcome, would arise at the expansion stage, she chooses to issue debt that serves as a self-disciplinary tool. But such an outcome is more likely to arise when firms have more profitable investment opportunities, as illustrated by Figure 1. This prediction is basically in line with the results of the above-mentioned theories such as the trade-off theory, the signaling-based theory, and the mechanism based on the fact that debt can be used as a commitment device.

However, the empirical evidence regarding the relationship between a firm's future profitability and its leverage is inconclusive. In the literature, Titman and Wessels (1988), Rajan and Zingales (1995), Fama and French (2002), and Frank and Goyal (2008) find that profitability and financial leverage are generally negatively associated with each other, which is more aligned with the views of of Jensen and Meckling (1976) and Myers (1977). On the other hand, Harris and Raviv (1991) find that announcements of increasing the debt level have been accompanied with a rise in share prices. Masulis (1980) also documents that an increment in leverage led to rises in share prices and firms values. For a more detailed survey on this topic, see also Graham and Leary (2011).

In this regard, we may need to use an alternative approach to test our model implications. Note that our model predicts that a separating equilibrium will be more likely to arise when firms issue more debt ex ante, while a pooling equilibrium or the no-investment equilibrium is more likely to emerge in other cases. As such, to test this prediction, we may investigate whether the stock prices or firm values of different firms exhibit larger gaps in subsequent periods after those firms increase leverage. This alternative method, which does not involve a direct examination of the relationship between profitability and leverage, can be used to assess the validity of our model.

5 Conclusions

In this paper, we introduce a new mechanism through which firms can use debt financing as a commitment device to increase the firm value when markets face information asymmetry. Specifically, we develop a model in which firms have investment opportunities in two projects. The investment opportunity for the first project arrives today and that for the second project arrives at a later date. The quality of the projects or the firm is realized between the start-up stage and the expansion stage. But the firm's quality is only privately known to the firm's equityholders. Thus, the firm's equityholders may have incentives to mimic high-type firms upon decovering their own projects would not be profitable. This outcome is not optimal from the ex-ante perspective. So, to prevent this outcome, the firm's initial owner may prefer to issue debt because this deliberately created debt burden will refrain herself and other equityholders from mimicking the high-quality firms ex post. The model predicts that firms in a more profitable industry will issue more debt ex ante because a pooling equilibrium would be more likely to occur in such an industry, if those firms have not issued any debt. Our model also implies that stock prices or firm values will exhibit a larger gap across different firms as time goes by if firms issue more debt ex ante, because such a behavior will induce the separating equilibrium. This prediction can be used to test the implications and validity of our model.

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