

# **Financial Flexibility and Limited Recourse Project**

## **Finance**

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October 2001

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# Financial Flexibility and Limited Recourse Project Finance

## Abstract

This paper analyses the optimal structure for arranging debt financing when a firm possesses private information about a set of investment opportunities. The key choice considered in the firm's structuring decision is whether to channel financing of projects through a set of subsidiaries where individual projects are segregated for financing purposes or to keep all projects and financing together in a unitary structure. One of the particular objectives in this paper is to analyze theoretically the optimality of limited or no recourse debt project finance arrangements.

In a simple dynamic model of financing under asymmetric information, I examine the implications of restricting liability to assets and cash flows of particular project, for the firm with *current* and *future* investment opportunities. I characterize private information settings where using non-recourse debt arrangement for the current project enhances financial flexibility of the firm in financing future growth opportunities. Here the use of the contract with project specific liability allows to decrease "effective" promised payments and external financing needs at the future date in states with high information costs and reduces the overall costs of financing. On the other hand, under conditions of asymmetric information about the quality of the current project, the choice of the debt financing mode may serve itself as a signal of quality. In particular, I demonstrate that there exists an equilibrium in which a firm with a high quality current project willingly forgoes the financial flexibility provided by the use of non-recourse debt and issues full recourse straight debt without project specific liability to separate itself from the lower quality firm.

# 1 Introduction

This paper analyses the optimal structure for arranging debt financing when a firm possesses private information about a set of investment opportunities. The key choice considered in the firm's structuring decision is whether to channel financing of projects through a set of subsidiaries where individual projects are segregated for financing purposes, or to keep all projects and financing together in a unitary structure.

This problem is similar to the one faced by an entrepreneur with access to several projects: Should he structure these projects under one firm, or should he form separate corporations to run them? An ongoing firm with assets in place and future growth opportunities faces a similar question regarding a current project. Although senior corporate officers pay close attention to these issues, corporate finance theory has little to say about them. For example, the starting point of discussions that invoke the principle of value additivity is that the choice of incorporation of an additional project is irrelevant. However, in this paper, I study a setting in which project incorporation decisions are important for firm management.

One of the specific objectives of this paper is to analyze theoretically the optimality of limited or no recourse debt project finance arrangements, often referred to simply as "project finance". Project finance can be defined as the financing of a project by a sponsoring firm where the cash flows of the specific project are earmarked as the source of funds from which the loan will be repaid and where the assets of the project serve as the collateral for the loan<sup>1</sup>. The project is legally distinct from the sponsors. The project debt does not appear on the balance sheet of the sponsoring firm and there is also no potential

liability to the project sponsor for the debts or liabilities of the project<sup>2</sup>. It is this “decreased effective liability” feature of project finance arrangement and its optimality that will be the focus of my analysis.

Project finance has been growing in importance. During the last two decades a fairly active market developed in the private placement of limited recourse debt. In fact, private companies invested \$96 billion in project finance deals in 1998.<sup>3</sup> The technique has been successfully used to fund a wide range of activities, from real estate development, oil and gas exploration and independent power generation facilities to manufacturing plants and even research and development efforts.

*Nonrecourse* financing is just one extreme of the continuum of financing possibilities. At the other extreme, in conventional *corporate financing*, lenders rely on the overall creditworthiness of the enterprise financing a new project to provide them security; the benefits of “co-insurance” taking place among the firm’s different business units under this traditional form of financing might result in lower cost of capital.

Between the two extremes are numerous possibilities for structuring financing for the project. For example, under the technique called “structured” project financing, the sponsor might assume some risk in the project in return for the reduction in the risk premium. By imposing limited obligations and responsibilities on the sponsor, this mode of financing involves at least some degree of corporate or balance sheet support, usually contingent and limited in time. Another technique involves “pooled project financing”, under which a “synthetic” balance sheet is effectively created. Here the debt from a number of individual projects is pooled into a single debt security resulting in the cross-collateralization of cash flow from the projects, but not cross-collateralization of assets.

While these innovative structures and instruments have generated great interest, I will focus on the analysis of the two most distinct financing modes, straight (full recourse) debt and project finance (no recourse) debt.<sup>4</sup>

The central issue in the paper is the enhancement of financial flexibility in funding future growth opportunities within the firm. For concreteness, consider a firm that initially has an investment project and expects to generate, at some future date, other investment opportunities about which the manager will have private information. Starting with the premise that the financing of a risky project under asymmetric information is costly, I address the issues of optimal debt contracting by shifting attention from the project being funded, onto the projects in the opportunity set of the corporate sponsor.

I show that the manager aligned with residual claimholders chooses a financing mode that minimizes current and *expected* future external financing costs. Restricting liability to the assets and cash flows of a particular project or set of projects by choosing contracts with project specific liability, might have two important consequences for the firm with current and future investment opportunities. On one hand, the ability to redistribute “effective” promised payments and external financing needs across states with different expected financing costs, may provide means to enhance financial flexibility of the firm in financing *future* growth opportunities. On the other hand, under conditions of asymmetric information about the quality of the current project, the choice of the debt financing mode may itself serve as a signal of quality.<sup>5</sup> In particular, I demonstrate that when both effects are taken into account, there exists an equilibrium in which a high quality firm forgoes the financial flexibility provided by the use of non-recourse project finance debt and issues full recourse straight debt to separate itself from the low quality

firm and reduce asymmetric information costs of the current financing at the expense of “suboptimal” future financing costs.

The optimal way to organize a multiproject firm has been addressed frequently in the economics and finance literature, though mostly through the analysis of conglomerate mergers.<sup>6</sup> On the other hand, there has been little rigorous analysis of project finance in the academic literature in spite of its increasing popularity and rich accumulated practitioners’ experience in the area.

Chemmanur and John (1996) analyze issues of optimal incorporation and the structure of the debt contract in an integrated model based on the considerations of corporate control. Their framework provides a rationale for project finance arrangements even in the situations where the extent of asymmetric information is not significant. They show that as the use of debt allows manager to avoid selling outside equity, thus lowering the probability of losing control to outsiders, limited recourse debt financing is optimal if management’s control benefits differ significantly from one project to another, while the relative abilities to manage the projects remain similar.

John and John (1991) and Flannery, *et al.* (1993) argue that project financing arrangements result from the firm’s efforts to minimize the impact of agency problems which may lead to underinvestment (as in Myers (1977)) or asset substitution (as in Jensen and Meckling (1976)). In my current paper I abstract from those agency problems, and show that there is value to non-recourse financing even if one ignores the possible distortions in the firm’s investment incentives caused by risky debt.

Finally, Shah and Thakor (1987) develop a signaling model of optimal capital structure based on corporate taxes and asymmetric information, under which riskier firms

adopt higher debt levels in the equilibrium. While their model is consistent with project finance arrangements for projects imposing high information asymmetry costs, it does not explain the use of project finance for projects that entail only symmetric uncertainty.<sup>7</sup>

The rest of the paper is organized as follows. The next section introduces the model. Section 3 analyzes the financing decision under asymmetric information at the future date and characterizes a costly signaling separating equilibrium. Section 4 analyzes the firm's choice of financing mode for the risky project at the initial date. Section 4.1 analyzes the case of informational symmetry, while Section 4.2 examines the case of informational asymmetry regarding the investment opportunity at the initial date. Section 5 concludes. Some proofs and results are relegated to the Appendix.

## **2 The Basic Model**

A two-period, three-date setting is considered with dates indexed by  $t = 0, 1, 2$  (see Figure 1.) All agents in the economy are risk-neutral and the risk-free interest rate is zero. At dates  $t=0$  and  $t=1$ , the manager has access to positive net present value (NPV) projects with exogenously given fixed initial investment outlays. Investment needs can be financed by issuing claims on current and/or future projects. Financial markets are competitive in that, whenever possible, projects are financed at zero expected profits for investors.

Next, I describe the characteristics of the firm's projects and then I turn to the financial instruments available to the firms.

### **2.1 Firm's Investment Opportunities**

At date  $t=0$ , the firm can invest in a risky Project 1, requiring an initial investment of  $I$  and generating cash flows at  $t=1$ . For simplicity I assume that the cash flow distribution at date  $t=1$  has the two point support,  $\{L, H\}$ , where  $H > I > L$ . Initially I assume that Project 1 is a transparent investment opportunity, in the sense that the probability  $q$  of realizing the high cash flow at  $t=1$  is common knowledge. In Section 4.2 of the paper I relax this assumption and consider a more general setting with asymmetric information on Project 1.

At the same time as the firm has a transparent investment Project 1, it also has the potential to develop other opportunities at the future date,  $t=1$ , about which management will have important private information at that date. Thus, financing the investment opportunity that opens up to the firm at  $t=1$ , Project 2, will entail adverse selection costs. Project 2 requires an initial outlay of  $i$  and also has two point return distribution,  $\{l, h\}$ , where  $h > i > l$ . There are two types of the second period projects, “good” and “bad”, which differ in the probabilities of realizing cash flow  $h$  ( $p_g$  and  $p_b$ , correspondingly). Output of each project is public information.

Ex ante, at  $t=0$ , both the manager and the market have the following priors about Project 2 quality: conditional on the outcome  $S$  of Project 1, at  $t=1$  Project 2 is expected to be of good type (“g”) with probability  $\rho^S$  and of bad type (“b”) with probability  $(1 - \rho^S)$ , where  $S = \{H, L\}$ . The manager learns the exact type of the second project at  $t=2$ .<sup>8</sup> At that date, outside investors assign probability  $\rho^H$  that the second project is type “g” after observing  $H$ -cash flow realization from Project 1 and probability  $\rho^L$  that the second project is type “g” after observing  $L$ -cash flow realization from Project 1. Henceforth I will refer to the states at  $t=1$  as the  $H$ -state and  $L$ -state.

As is shown in the Appendix (Result 4.1.1), for  $\rho^H > \rho^L$ , the conditional probability of the second project succeeding is higher given Project 1's success than given Project 1's failure; thus, projects exhibit "cyclicalit". On the other hand, for  $\rho^H < \rho^L$ , conditional probability of the second project succeeding is higher given the failure of the first project than its success; thus projects exhibit "countercyclicalit".

I will make further assumptions about firm's type distributions and cash-flow streams along the way. I begin by assuming that all firms have positive net present value projects at both dates and that those projects are profitable enough that the manager of either type is willing to undertake the second project both when success or failure of the Project 1 occurs at date  $t=1$ . This assumption allows me to abstract from the possible agency problems caused by risky debt resulting in a suboptimal investment strategy and to concentrate on the issues of flexibility in raising external financing.

## 2.2 Firm's Financial Options

In order to finance investments, the firm issues claims against the cash flows from Project 1 and/or Project 2. I allow firms to choose between two forms of financing: straight debt or non-recourse debt.<sup>9</sup> The main distinguishing features of these instruments are the following:

1. **Straight debt:** Straight debt issue at date  $t = n$  specifies a payment,  $F^J$  to creditors of the *firm* at date  $t=n+1$ , which is a binding obligation. Straight debt presents a claim with full recourse; if the firm does not meet the payment at date  $t=n+1$  the firm is declared bankrupt, gets liquidated and the valuable second project cannot be

undertaken. The firm can choose to pay off the balance of the obligation to the date 1 claimants,  $(FJ - L)$ , with the proceeds from a new issue secured by the cash flows from the future project, thus increasing the amount of external funds raised at  $t=n+1$  above the investment outlay for the second project. I assume that the firm is always able to refinance the first period shortfall, therefore making the straight debt issue riskless.<sup>10</sup>

2. **Project finance debt:** A project finance non-recourse debt issue at  $t = n$  specifies a payment,  $F^{PF}$  to the creditors of the *project* at date  $t=n+1$ . Here the payment depends only on the payoffs of the project under consideration. The contract specifies that the lenders have no recourse to the sponsoring firm in the event of default on the obligations of the project being financed under nonrecourse arrangement, therefore the firm is not liquidated even if it declares bankruptcy on Project 1 in  $L$ -state.

Notice that the choice between these two financing instruments is relevant only at date  $t=0$ , since I assume that the firm is liquidated at  $t=2$ , when the proceeds of the second project come in.<sup>11</sup>

There are several issues that should be addressed here. First of all, I assume that each project is capable of functioning profitably as an independent economic unit and does not rely on any assets that are an integral part of another project. Thus, each project includes all the facilities that are necessary to constitute a viable operating entity. There are no synergies/dissynergies from joint or separate incorporation of current and any future projects.

Second, since the firm expects to incur signaling costs in the future, it might choose to raise more external financing than it needs to finance current investment at  $t=0$  (“overfinance”) and just carry over any surplus to the next period, investing it in the zero-NPV financial assets. However, there is possible seepage of value with such “overfinancing”. The potential costs of storing extra funds might include a negative tax effect on the returns from investment in financial assets, which is usually viewed as the investment not related to the purpose of the business (the tax on “Improper Profit Accumulation”) or potential agency problems of “free cash flow” such as diversion of funds on perk consumption, etc. I assume that these costs are high enough to make “overfinancing” suboptimal.

Finally, to exclude trivial cases I assume that using the proceeds from Project 1 cannot completely eliminate the need for raising risky funds for Project 2.<sup>12</sup>

Because the securities market is competitive, security prices are set so that investors (on average) break even. Thus, under rational pricing, in the absence of asymmetric information regarding the project’s cash flows, the firm’s financing decision is irrelevant. Indeed, it can be shown that the choice of straight or non-recourse debt only effectively redistributes the firm’s earnings, and therefore external financing needs, across states. Under project financing, while sponsors are protected by limited liability when the project fails (in the  $L$ -state), the investors know that their rewards depend exclusively upon the performance of the project, and charge appropriately for the risks they bear. Therefore, in the project-financed deal, the firm has to pay higher (than under straight debt) face value in the state where the project succeeds ( $H$ -state), thus reducing the amount of retained funds that can be used for the second period financing. I demonstrate further how the non-

recourse or full recourse feature of the first period claim becomes important under present or expected conditions of asymmetric information by allowing the manager to choose the financing mode that minimizes the overall current and future asymmetric information cost of raising external funds.

### **3 Second Stage Financing**

I solve the model backwards and start at the beginning of the second period,  $t=1$ . At this date the type of Project 2 is revealed to the manager, while the investors, upon observing outcome  $S$  of Project 1 ( $S = H$  or  $S = L$ ), attach probability  $\rho^S$  that Project 2 is of the good type (see Figure 1.) As the firm needs to raise funds externally under conditions of asymmetric information, the firm's risky claims may be mispriced by the market.

Although private information regarding the project itself cannot be conveyed to the market, the financial decisions of the firm can provide information to market participants and the high quality firms might have incentives to engage in costly signaling to reveal their type. Below I consider such a signaling equilibrium, where the signaling action is purely dissipative, meaning that it provides no direct benefits to the signaling firm, and is equally costly for all types.<sup>13</sup> One possibility for such a signaling cost would be a nonpecuniary cost similar to the one considered in Diamond (1984). The costly signal might be seen, for example, as a precommitment to the contract restricting manager's private benefits.

The timeline for the signaling game is illustrated in Figure 2. The manager who has private information about the type of his project raises external funds  $w$  at  $t=1$  to

finance investment and any outstanding obligations. At the same time he can also commit to incur signaling cost  $\Delta$ , to convey his type. At  $t=2$  the investment pays off, claims are settled, signaling costs are suffered and the firm is liquidated. In this section I assume that the manager attempts to finance the investment opportunity with the issuance of risky debt. In the Appendix (see Proposition 3.1), I show that under equity financing, signaling entails higher costs and therefore is less efficient than under debt financing.

### 3.1 Signaling Equilibrium

Let  $f_b$  and  $f_g$  be the face values of the debt claims for the bad and good types correspondingly.

In this game, a strategy for the firm is a function from its type space  $\theta = \{g, b\}$ , into the signaling space,  $\Delta \in \mathbf{R}^I$ . A strategy for the creditor is a function from the signaling space, into the contract space in  $\{f_g, f_b\}$ . Define the belief held by the creditor after observing the costly signal  $\Delta$  given by the firm as the following: let  $\varphi(\Delta)$  be the creditor's assessment of the probability that  $\theta = g$ . A perfect Bayesian equilibrium in this game is a pair of strategies and a belief function for the financial market, satisfying two conditions:

*Condition 1. (i) Given its type and given the creditor's strategy, the firm's strategy maximizes its expected payoff. (ii) Given the signal  $\Delta$ , and given the creditor's belief,  $\varphi(\Delta)$ , the creditor's strategy maximizes its expected payoff.*

*Condition 2. When possible, the belief  $\varphi(\Delta)$  is derived from Bayes' rule and the firm's strategy.*

Condition 2 implies that upon seeing signaling level  $\Delta(\theta=b)$ , the creditors must assign probability equal to one that the firm is type “b” and likewise, upon seeing signal level  $\Delta(\theta=g)$ , the creditors must assign probability equal to one that the firm is type “g”. In the two type model it can be shown that there exists a level of costly signal such that upon observing the signal, the market updates its belief to  $\varphi(\Delta) = 1$  and offers a contract with a lower face value,  $f_g$ . Otherwise, the contract offered has a face value  $f_b$ . The good type is strictly better off by signaling and a bad type firm chooses not to signal.<sup>14</sup>

In such a signaling equilibrium, the payoffs to the firms depending on their type (either “g” or “b”) and on their action (denoted by a superscript  $\Delta$  if they commit to costly signaling) are:

$$\pi_g^\Delta = p_g (h - f_g) - \Delta$$

$$\pi_g = p_g (h - f_b)$$

$$\pi_b^\Delta = p_b (h - f_g) - \Delta$$

$$\pi_b = p_b (h - f_b)$$

For the signaling equilibrium to exist, incentive compatibility constraints must be satisfied, meaning that there must exist a  $\Delta$ , for which  $\pi_g^\Delta > \pi_g$  and  $\pi_b^\Delta \leq \pi_b$ , with the equality holding for the most efficient signal level:

$$p_b (h - f_b) \geq p_b (h - f_g) - \Delta$$

$$p_g (h - f_b) < p_g (h - f_g) - \Delta$$

The first constraint above requires that the payoff to the bad type firm if he mimics the good type will be no higher than his payoff if he does not mimic and the second constraint

requires that the payoff to the good type if he signals is higher than his payoff if he does not.

Therefore, the signal level should satisfy:

$$\Delta \geq p_b(f_b - f_g)$$

$$\Delta < p_g(f_b - f_g).$$

A separating equilibrium must also guarantee the creditor nonnegative expected profit; in fact the creditor earns zero profit on each contract under the assumption of a competitive market for the firm's claims. Thus, if the firm raises  $w$  funds, the creditor's zero-profit constraints are:

$$p_g f_g + (1 - p_g) l = w$$

$$p_b f_b + (1 - p_b) l = w.$$

Solving these equations for face values  $f_b$  and  $f_g$  and substituting into the incentive compatibility constraints above yields<sup>15</sup>:

$$\Delta^{\text{DEBT}} = (w - l)(1 - p_b/p_g).$$

The intuition behind this equilibrium is the following. The signaling action is equally costly for all firms regardless of their type.<sup>16</sup> On the other hand the expected benefit from getting a debt contract with a lower face value as a result of signaling is higher for the good type. Indeed, since the benefit of having a lower face value for any type is realized only in the h-state (solvent state) of the risky project, the expected benefit from signaling is directly proportional to the probability  $p_\theta$  of reaching that state, which is strictly higher for the good type.

The above discussion is summarized in the following proposition

**Proposition 1:** *Under debt financing, there exists a separating equilibrium where the firm with the good type project engages in costly signaling. The efficient signal level is increasing in the amount of funds raised,  $w$ , and is given by:  $\Delta = (w - l)(1 - p_b/p_g)$ .*

#### **4 Optimality of Non-Recourse Debt Financing**

In this section I analyze the firm's choice of optimal financing instrument at the initial date,  $t=0$ . As discussed in Section 2.2, at this initial date the manager can either issue a straight debt claim with full recourse to the current and future projects of the firm or a separate debt claim on Project 1, without recourse to the other projects of the firm. If at time  $t=1$  the private information is good, the manager will commit to costly signaling and incur the signaling cost derived in the previous section to reveal his type.

With the manager's objective being to maximize the intrinsic value of equity as of date  $t=0$ , his choice of financing instrument at  $t=0$  will be based on minimizing the expected cost of raising funds at both dates,  $t=0$  and  $t=1$ , since, as it will be shown later, the expected cost of external financing for future project is also affected by the mode of financing the initial project.

Under symmetric information on the Project 1, the effect of the first period claim structure on the external financing costs comes about only through its effect on the redistribution of the needs for external financing at date  $t=1$  across states with different expected asymmetric information costs. In Section 4.2, I analyze the setting with asymmetric information on both projects, where the choice of the financing instrument for

Project 1 also affects the cost of raising funds at the initial date. I will show that with a sufficiently high degree of asymmetric information at the initial date, a separating equilibrium will obtain, where the firm with a Good type initial project takes on a “harder” debt contract without project specific limited liability, while a firm with a Bad type initial project willingly signals its quality by engaging in nonrecourse project financing.

#### 4.1 Symmetric Information at $t=0$

Under symmetric information at  $t=0$ , the choice of the security issued at that date is determined only by the effect it will have on the expected future external financing needs.

Given the assumptions and definitions of the model, the face value of the debt claim on the first project,  $F$ , is the solution to:

$$I = q F + (1 - q) Z, \tag{1}$$

where

$$Z = \begin{cases} L + (F - L), & \text{for straight full-recourse debt} \\ L, & \text{for non-recourse project finance debt} \end{cases} \tag{2}$$

Equation (1) equates the amount of borrowing to the expected return to the debtholders. Equation (2) uses the definition of the full- and non-recourse debt claims and the assumption that the firm always has profitable enough investment opportunities to refinance outstanding obligations at date  $t=1$ . By rearranging (1) we obtain

$$F = (I - (1-q)Z)/q.$$

Or,

$$\begin{cases} I, & \text{for straight full-recourse debt} \end{cases}$$

$$F = \frac{I - (1-q)L}{q}, \quad \text{for non-recourse project finance debt}$$

Using the notation  $F^J$  for the face value of straight debt and  $F^{PF}$  for the face value of non-recourse debt we obtain:

$$F^J = I, \text{ and } F^{PF} = \frac{I - (1-q)L}{q}, \text{ with } F^{PF} > F^J. \quad (3)$$

Let  $w$  be the external financing needs at  $t=1$ . It is easy to see that  $w$  is equal to required outlay for Project 2, less retained earnings from Project 1, plus an amount needed for paying off any outstanding liabilities.<sup>17</sup> Therefore,  $w$  is a function of the cash flow realization of the Project 1 at  $t=1$  and the choice of financial instrument at  $t=0$ .

For the full recourse claim,

$$w^J = \begin{cases} i - (H - F^J) = i+I - H, & \text{if Project 1 is in the H-state} \\ i + (L - F^J) = i+I - L, & \text{if Project 1 is in the L-state,} \end{cases} \quad (4)$$

and for the non -recourse claim,

$$w^{PF} = \begin{cases} i - (H - F^{PF}) = i+(I - (1-q)L)/q - H, & \text{if Project 1 is in the H-state} \\ i & \text{if Project 1 is in the L-state} \end{cases} \quad (5)$$

Comparing (4) and (5), one can see that the choice of straight or non-recourse debt only redistributes the firm's earnings and financing needs across states without changing the expected payoff from Project 1. Indeed under rational pricing and symmetric information, the project can be sold at a fair price with either kind of security, imposing no asymmetric information costs on the firm. Under project finance, while sponsors are protected by the limited liability when the project fails, the investors know that their rewards depend exclusively upon the performance of the project, and charge appropriately

for the risks they bear. Therefore, in the project-financed deal, the firm has to pay sufficiently higher (than under straight debt) face value in the state where the project succeeds, thus reducing the amount of funds that can be retained and used for the second period financing. On the other hand, if the manager issues a full-recourse claim, while enjoying a lower face value, the firm has to repay the obligations of the Project 1 in both states, thus increasing the need for costly external financing at date  $t=1$  in the L-state of the Project 1 above the amount needed for investment outlay for Project 2 at  $t=1$ .

Next, to derive the condition for the optimal claim at  $t=0$ , consider the expected (market) value of equity under both forms of financing. For the full recourse claim, the expected equity value at  $t=0$  is:

$$\begin{aligned}
 EJ = & \text{signaling costs} \\
 & q[\rho^H(p_g h + (1-p_g)l - (i - (H - I)) - (i-l-H+I)(1 - p_b/p_g) \\
 & + (1 - \rho^H)(p_b h + (1-p_b)l - i + (H-I) ] \\
 & + (1-q) [\rho^L (p_g h + (1-p_g) l - (i + (I - L)) - (i-l-L+I)(1 - p_b/p_g) \\
 & + (1 - \rho^L) (p_b h + (1-p_b)l - i) - (I - L)] \\
 (6)
 \end{aligned}$$

Rearranging the terms in (6):

$$\begin{aligned}
 EJ = & \text{exp. NPV of Project 1} + \text{exp. NPV of Project 2} \\
 & \{qH + (1-q)L - I\} + \{q[\rho^H(p_g h + (1-p_g)l - i) + (1 - \rho^H)(p_b h + (1-p_b)l - i) ] \\
 & + (1-q) [\rho^L (p_g h + (1-p_g) l - i) + (1 - \rho^L) (p_b h + (1-p_b)l - i)] \} \\
 & - \text{signaling costs in H-state} - \text{signaling costs in L-state} \\
 & - q \rho^H (i-l-H+I)(1 - p_b/p_g) - (1-q) \rho^L (i-l-L+I)(1 - p_b/p_g) \quad (7)
 \end{aligned}$$

Similarly for the non-recourse claim,

$$\begin{aligned}
 EPF = & \text{signaling cost} \\
 & q[\rho^H(p_g h + (1-p_g)l - (i - (H-(I-L)/q - L)) - (i-l-H+(I-L)/q+L)(1 - p_b/p_g)
 \end{aligned}$$

$$\begin{aligned}
& + (1 - \rho^H)(p_b h + (1 - p_b)l - i + (H - (H - (I - L)/q - L))) \\
& + (1 - q) [\rho^L (p_g h + (1 - p_g)l - i - \overset{\text{signaling costs}}{(i - l)(1 - p_b/p_g)})] \\
& + (1 - \rho^L) (p_b h + (1 - p_b)l - i)
\end{aligned} \tag{8}$$

Or, rearranging the terms in (8),

$$\begin{aligned}
& \text{exp. NPV of Project 1} \qquad \qquad \qquad \text{exp. NPV of Project 2} \\
\text{EPF} = \{ & qH + (1 - q)L - I \} + \{ q[\rho^H(p_g h + (1 - p_g)l - i) + (1 - \rho^H)(p_b h + (1 - p_b)l - i)] \\
& + (1 - q) [\rho^L (p_g h + (1 - p_g)l - i) + \overset{\text{exp. NPV of Project 2}}{(1 - \rho^L) (p_b h + (1 - p_b)l - i)}] \} \\
& - q \rho^H \overset{\text{signaling costs in H-state}}{(i - l - H + (I - L)/q + L)(1 - p_b/p_g)} - \overset{\text{signaling costs in L-state}}{(1 - q) \rho^L (i - l)(1 - p_b/p_g)}
\end{aligned} \tag{9}$$

Define  $\Delta \Phi$  to be the difference between the expected equity value of these two strategies, or:

$$\Delta \Phi = \text{EPF} - \text{EJ}$$

Then,

$$\begin{aligned}
\Delta \Phi = & - q \rho^H (i - l - H + (I - L)/q + L)(1 - p_b/p_g) - (1 - q) \rho^L (i - l)(1 - p_b/p_g) \\
& + q \rho^H (i - l - H + I)(1 - p_b/p_g) + (1 - q) \rho^L (i - l - L + I)(1 - p_b/p_g).
\end{aligned} \tag{10}$$

Collecting terms in (10):

$$\Delta \Phi = (1 - q) (I - L) (1 - p_b/p_g) (\rho^L - \rho^H) \tag{11}$$

Thus,  $\Delta \Phi > 0$  and the expected value of equity is higher under project finance arrangement, for  $\rho^L > \rho^H$ . On the other hand,  $\Delta \Phi < 0$  and the expected value of firm's equity is higher under financing with straight debt for  $\rho^L < \rho^H$ .

The above results can be summarized in the following proposition:

**Proposition 2:** *Firms facing potential asymmetric information in the future will choose to issue non-recourse project finance debt for  $\rho^L > \rho^H$  and full-recourse straight debt for  $\rho^L < \rho^H$ .*

The intuition for the above result is the following. As the manager expects a higher probability of having good private information and therefore incurring asymmetric information costs in state  $S$  at date  $t=1$ , he chooses the mode of financing that minimizes the needs for external costly financing in that state at the expense of higher financing needs in the state with lower probability of incurring adverse selection premium. Thus if the projects coming at two consecutive points in time are “countercyclical” (for  $\rho^L > \rho^H$ , see Section 2.2), the manager chooses the non-recourse project finance debt claim to limit the obligations in the  $L$ -state where the first project fails and where the conditional probability  $\rho^L$  of getting a good quality second period project, and therefore incurring asymmetric information costs, is high. This is done at the expense of higher face value paid and therefore lower internal funds available in the  $H$ -state, where the probability of incurring adverse selection costs ( $\rho^H$ ) is lower. On the other hand, for “cyclical” projects (with  $\rho^L < \rho^H$ ), as the manager expects higher asymmetric information costs in the  $H$ -state, where the first project succeeds, he chooses straight debt, reducing the face value paid and therefore increasing internal funds that can be used to subsidize future investment in that state. This comes at the expense of additional costly external financing needs due to the necessity to refinance any shortfall from the first project in the  $L$ -state where the probability of getting high quality project at  $t=1$  and incurring asymmetric information costs is lower for  $\rho^L$  than  $\rho^H$ .

Notice that  $|\Delta\Phi|$  can be interpreted as the measure of the value of being able to split “effective” promised payments across states with different expected asymmetric information costs in the manner minimizing the expected external financing costs by using the contracts with different degree of recourse. I will interpret  $|\Delta\Phi|$  as the “financial flexibility value”. Under symmetric information at the date of the initial financing, the firm will always choose the debt mode that is optimal from the point of view of financial flexibility. In the next section I will show that under information asymmetry at the initial date, the firm might choose to forego the financial flexibility benefits and precommit to incur a “suboptimal” level of future financing costs to convey its type at  $t=0$ .

## 4.2 Asymmetric Information at $t=0$

In this section I relax the assumption of symmetric information at  $t=0$ . Specifically, I augment the basic model by allowing two types of projects at  $t=0$ , “Good” and “Bad” (G-type and B-type), where the types differ in their probability of achieving H-state ( $q_G$  and  $q_B$ , correspondingly). Further, I will use “G” and “B” to denote date  $t=0$  types and “g” and “b” to denote date  $t=1$  types. While at  $t=0$  the manager of the firm knows the type of Project 1 at  $t=0$ , outside investors have only a common probability distribution for  $q$ .

Let the menu of the second period projects be the same as outlined in the Basic Model, with the conditional probability that the second project is of the “good” type at  $t=1$ , given that the Project 1 is in H-state, being  $\rho^H$  for both G-type and B-type. Correspondingly  $\rho^L$  is conditional probability that the second project’s type is “good” given that Project 1 is in L-state for both G-type and B-type.<sup>18</sup>

In this particular setting the parameter  $(\rho^H - \rho^L)$  can be also interpreted as an asymmetric information “time consistency” factor. As it is shown in the Appendix (Result 4.2.1), for  $(\rho^H - \rho^L) > 0$ , the firm with a Good type project at  $t=0$  also has higher expectations about quality of the project coming at  $t=1$  than the firm with a Bad type project at the initial date  $t=0$ . For  $(\rho^H - \rho^L) < 0$ , the firm with a Bad type Project 1 has higher expected probability of having good quality project at the future date than the firm with a Good type initial project.

I now characterize the equilibria of the first period financing.

First, for  $\rho^L < \rho^H$ , there exists only a pooling equilibrium in which both types of firms prefer to issue straight debt. Indeed, since under the assumptions of the model the straight debt claim is riskless, it entails no asymmetric information costs for either type of firm at  $t=0$ .<sup>19</sup> Therefore both types will fully utilize the financial flexibility value in (11) by choosing the form of financing that minimizes expected asymmetric information costs at  $t=1$ , which has been shown to be straight debt for  $\rho^L < \rho^H$ .

For  $\rho^L > \rho^H$  there exists a fully revealing separating equilibrium in which the firm’s Project 1 type at  $t=0$  is fully revealed through its financing mode choice at that date. Later I concentrate on asymmetric information structure at  $t=0$  with  $\rho^L > \rho^H$ . Then under *symmetric* information, the firm minimizing its expected asymmetric information costs will issue project finance debt (see *Proposition 2*). I will show that under *asymmetric* information at  $t=0$ , there exist parameter values that support a separating outcome in which straight debt is issued. In this separating equilibrium, a straight debt issue signals favorable information about Project 1.

I examine a separating outcome in which the firm issues project finance debt at  $t=0$  if it has Bad type Project 1 and straight debt if the Project 1 type is Good. For this outcome, where the project finance debt is priced as if it were issued by the Bad type and straight debt is priced as if it were issued by the Good type, to be supported by an equilibrium, it must be the case that the overall financing costs in both periods are minimized with a straight debt contract at  $t=0$  for the Good type firm and with a project finance contract at  $t=0$  for the Bad type firm.

Consider the decision of the firm with the Bad type Project 1 at  $t=0$ . Under the assumptions of the model, straight debt is riskless and, therefore, there are no asymmetric information costs for date  $t=0$  financing for either type. Now as the project finance debt claim is priced as if it were issued by the Bad type, the Bad type firm solves problem from the full information setting and chooses project finance debt for  $\rho^L > \rho^H$ .

The Good firm's decision is now somewhat different, since the choice of financial claim issued at date  $t=0$  affects not only the expected costs of financing at  $t=1$ , but also the adverse selection cost of financing at  $t=0$ . If the firm chooses the non-recourse claim, it will be priced as a Bad type and will have to pay a higher face value in the H-state.

Consider the expected (private) equity value for the firm with a Good type Project 1 under financing with straight debt. Using Result 4.2.2 of the Appendix, we obtain:

$$\begin{aligned}
 E^J_G = & q_G [\overset{\text{signaling costs}}{\rho^H (p_g h + (1-p_g)l - (i-(H-I)) - (i-l-H+I)(1-p_b/p_g)} \\
 & + (1-\rho^H)(p_b h + (1-p_b)l - i + (H-I)] \\
 & + (1-q_G) [\overset{\text{signaling costs}}{\rho^L (p_g h + (1-p_g)l - (i+(I-L)) - (i-l-L+I)(1-p_b/p_g)} \\
 & + (1-\rho^L)(p_b h + (1-p_b)l - (i+(I-L))] \tag{12}
 \end{aligned}$$

Or, rearranging the terms in (12):

$$\begin{aligned}
& \text{exp. NPV of Project 1} \\
E_G^J = & \{q_G H + (1-q_G)L - I\} \\
& \text{exp. NPV of Project 2} \\
& + \{q_G [\rho^H (p_g h + (1-p_g)l - i) + (1-\rho^H)(p_b h + (1-p_b)l - i)] \\
& \text{exp. NPV of Project 2} \\
& + (1-q_G) [\rho^L (p_g h + (1-p_g)l - i) + (1-\rho^L)(p_b h + (1-p_b)l - i)] \} \\
& \text{exp. signaling costs in H-state} \quad \text{exp. signaling costs in L-state} \\
& - q_G \rho^H (i-l-H+I)(1-p_b/p_g) - (1-q_G) \rho^L (i-l-L+I)(1-p_b/p_g) \quad (13)
\end{aligned}$$

For the non-recourse claim, using Result 4.2.2 of the Appendix for the face value of the debt claims, the Good type's private equity valuation is,

$$\begin{aligned}
E_G^{PF} = & q_G [\rho^H (p_g h + (1-p_g)l - \overset{\text{signaling costs}}{(i-H+(I-L)/q_B+L}) - (i-l-H+(I-L)/q_B+L)(1-p_b/p_g) \\
& + (1-\rho^H)(p_b h + (1-p_b)l - \overset{\text{signaling costs}}{(i-H+(I-L)/q_B+L})] \quad (14) \\
& + (1-q_G) [\rho^L (p_g h + (1-p_g)l - i - \overset{\text{signaling costs}}{(i-l)(1-p_b/p_g)} + (1-\rho^L)(p_b h + (1-p_b)l - \\
& i)]
\end{aligned}$$

Or, rearranging the terms in (14),

$$\begin{aligned}
E_G^{PF} = & \{q_G H + (1-q_G)L - I\} \quad \text{exp. NPV of Project 1 for Good type} \quad \text{"mispricing" of loan at } t=0 \\
& - (I-L)(q_G - q_B)/q_B \\
& \text{exp. NPV of Project 2} \\
& + \{q_G [\rho^H (p_g h + (1-p_g)l - i) + (1-\rho^H)(p_b h + (1-p_b)l - i)] \\
& \text{exp. NPV of Project 2} \\
& + (1-q_G) [\rho^L (p_g h + (1-p_g)l - i) + (1-\rho^L)(p_b h + (1-p_b)l - i)] \} \\
& \text{signaling costs in H-state} \\
& - q_G \rho^H (i-l-H+(I-L)/q_G+L)(1-p_b/p_g) \\
& \text{"extra" signaling costs in H-state} \\
& - q_G \rho^H (I-L)[(q_G - q_B)/(q_B q_G)](1-p_b/p_g) \\
& \text{signaling costs in L-state}
\end{aligned}$$

$$- (1-q_G) \rho^L (i-l)(1-p_b/p_g) \quad (15)$$

Let  $\Delta\Pi_G$  be the difference between the expected private equity value for the Good firm for these two financing strategies, or define  $\Delta\Pi_G = E^{PF}_G - E^J_G$ . Then,

$$\begin{aligned} \Delta\Pi_G = & -q_G \rho^H (i-l-H+(I-L)/q_G+L)(1-p_b/p_g) - (I-L)(q_G - q_B)/q_B \\ & - q_G \rho^H (I-L)[(q_G - q_B)/(q_B q_G)](1-p_b/p_g) - (1-q_G) \rho^L i(1-p_b/p_g) \\ & + q_G \rho^H (i-l-H+I)(1-p_b/p_g) + (1-q_G) \rho^L (i-l-L+I)(1-p_b/p_g) \end{aligned} \quad (16)$$

Collecting terms in (16) obtains:

$$\begin{aligned} \Delta\Pi_G = & \overset{\Delta\Phi_G}{(I-L)(1-q_G)(1-p_b/p_g)(\rho^L - \rho^H)} \\ & - (I-L)(q_G - q_B)/q_B - (I-L)\rho^H[(q_G - q_B)/q_B](1-p_b/p_g), \end{aligned} \quad (17)$$

where,  $(I-L)(1-q_G)(1-p_b/p_g)(\rho^L - \rho^H)$  is the financial flexibility measure for the Good firm under full information valuation, or  $\Delta\Phi_G$ .

Thus, the Good type firm's expected equity value is higher under a project finance arrangement for  $\Delta\Pi_G > 0$ , or for

$$\Delta\Phi_G > (I-L)(q_G - q_B)/q_B + (I-L)\rho^H[(q_G - q_B)/q_B](1-p_b/p_g), \quad (18)$$

and the Good type firm's expected equity value is higher under straight debt financing for  $\Delta\Pi_G < 0$ , or for

$$\Delta\Phi_G < (I-L)(q_G - q_B)/q_B + (I-L)\rho^H[(q_G - q_B)/q_B](1-p_b/p_g). \quad (19)$$

From condition (17) one can see that the Good firm's expected equity value is affected in three ways if it chooses project finance debt over straight debt at  $t=0$ . First, as in the full information setting (see condition (11)), the firm benefits from the project

specific liability allowing it to decrease external financing needs in the  $L$ -state where expected asymmetric information costs are higher at  $t=1$ . This is the financial flexibility value of the non-recourse debt for  $\rho^L > \rho^H$ , presented by the term  $\Delta\Phi_G$ . Second, since in this equilibrium outcome, the firm's project finance debt claim is priced as if it were issued by the Bad firm, the Good firm has to pay out a higher than under full information face value in  $H$ -state at date  $t=1$ , which decreases the payoff to the Good type firm from Project 1 and decreases the overall advantage of the project finance arrangement. This effect is captured by the second term in (17). Finally, as represented by the third term in (17), there is a further effect of mispricing of the non-recourse claim issued at  $t=0$ : since the firm has to pay out a higher face value, it also has less internal funds for investment at  $t=1$  in the  $H$ -state, which further increases the expected costs of financing at that date. Thus, the second and third effects described above tend to offset the financial flexibility advantage of project finance in the asymmetric information setting, while under symmetric information, the financial flexibility effect is the only one present. If the asymmetric information considerations for valuation at  $t=0$  and their spillover on the second period financing dominate the financial flexibility advantage of the nonrecourse debt, the combined impact of the three effects on the Good firm's expected equity value is negative and therefore the Good type firm will undertake straight debt financing. The above discussion is summarized in the following proposition:

**Proposition 3:** *For  $\Delta\Pi_G < 0$  and  $\rho^L > \rho^H$ , there exists a separating equilibrium in which the firm with a Good type Project 1 at  $t=0$ , issues straight (full recourse) debt and the firm with a Bad type Project 1, issues project finance (non-recourse) debt.<sup>20</sup> Otherwise, there*

*exist only pooling equilibria, where both types pool at straight debt for  $\rho^L < \rho^H$  and at project finance debt for  $\rho^L > \rho^H$  and  $\Delta\Pi_G > 0$ .*

The intuition behind Proposition 3 is as follows. The optimal financing strategy of the firm is determined by the variations in the informational asymmetry regarding components of its cash flows and the trade-offs between adverse selection costs and gains from contracts written on different components. Consider writing a debt contract at  $t=0$  only on the cash flows of risky Project 1 (project finance debt contract). If there is asymmetric information about these cash flows, the firm incurs adverse selection costs on the risky part of date  $t=0$  investment,  $(I-L)$ . The higher the degree of asymmetric information about Project 1 (the higher is  $q_G/q_B$ ), the more severe are the costs incurred. On the other hand, writing at  $t=0$  a straight debt contract with full recourse, makes the claim riskless from the point of view of date  $t=0$  creditors. Thus, under the straight debt contract, the firm does not incur adverse selection costs due to informational asymmetry about Project 1. At the same time, the firm has to refinance the shortfall  $(I-L)$  from the first project in the state where the project fails (L-state), by writing a contract on the cash flows of Project 2. Doing this entails adverse selection costs to the extent of asymmetric information about Project 2 cash flows. Now, the relative importance of gains and costs from writing either of those two contracts will be determined by the relative degree of asymmetric information regarding cash flows from Project 1 and Project 2 (or, cash flows at dates  $t=0$  and  $t=1$ ).

Recall that, at the same time, there is another possible source of gains or costs from writing non-recourse or straight debt contract, namely the redistribution of proceeds from

Project 1 across states with different expected asymmetric information costs, analyzed in detail in Section 4.1. Thus, the firm's overall financing strategy will be determined by trading off the adverse selection costs of external financing across dates and states.

Consider further the conditions in (18) and (19). Let the degree of asymmetric information at  $t=0$  be low ( $q_G \rightarrow q_B$ ). The financial flexibility value of non-recourse debt (adverse selection costs trade-off across states) dominates considerations about valuation at  $t=0$ . Here the Good type firm chooses the initial date financing mode that is optimal in the full information setting and pools with the Bad type firm by issuing non-recourse debt for  $\rho^L > \rho^H$ . As the degree of asymmetric information at  $t=0$  increases ( $q_G/q_B$  increases), there exists a nonempty set of parameters (defined by  $\Delta \Pi_G < 0$ ) for which the Good firm signals its quality by taking on a "harder" debt contract for  $\rho^L > \rho^H$ , one without project specific limited liability and avoids adverse selection costs at  $t=0$ . For a sufficiently high degree of asymmetric information at the initial date ( $q_G/q_B > 2$ ), the Good firm will always choose straight full recourse debt to separate itself. In such a separating outcome, in order to save on high adverse selection costs at  $t=0$ , the Good firm willingly gives up using the flexibility by doing straight debt financing and precommits to suffer suboptimal financing costs in the second period; while the Bad firm chooses what is optimal in the full information setting. Notice that the Good firms have a comparative advantage in choosing the suboptimal (for  $\rho^L > \rho^H$ ) straight full recourse claim at  $t=0$ . Since the Good firm has a higher probability of obtaining the H-state at  $t=1$ , the concern about refinancing the obligation from the first period claim in the state where Project 1 fails (L-state) is less critical than for the Bad type firm. Finally, the range of parameters for which a separating equilibrium with straight debt signaling high quality exists, depends on the riskiness of the

Project 1 at  $t=0$ . As  $q_G$  decreases (risk of Project 1 failing increases), the financial flexibility considerations, namely restricted liability in L-state, will become more important and the range of parameters supporting a separating equilibrium is smaller. On the other hand, for the safer projects, (with  $q_G \rightarrow 1$ ), financial flexibility considerations become less important and a separating equilibrium with the full-recourse claim as a signal will obtain for a larger range of parameters in (17). Thus, signaling with the issue of straight debt *per se* is more likely under a low degree of *symmetric* uncertainty but a high degree of *asymmetric* uncertainty on Project 1. At the same time, for sufficiently risky first period projects with low degree of *asymmetric* uncertainty, the issue of project finance debt by all types of firms becomes a more likely outcome.

## 5 Conclusion

This paper provides a framework to study the problem of establishing the optimal financial debt contract under asymmetric information and rational expectations. Two forms of debt financing with different degrees of “effective” liability are considered and conditions for the optimality of each form are derived. First, I show that restricting liability to particular project or set of projects may provide the extra means to enhance financial flexibility for the firm by allowing it to split “effective” promised payments and external financing needs between states with different expected asymmetric costs in the optimal manner. On the other hand, the issue of straight or project finance debt might itself serve as a credible signal of project quality. Taking both effects into consideration, I demonstrate that the use of claims with different effective liability allows the firm to

exploit profitably the variability in informational asymmetries regarding different components of its cash flows across states and time. In particular, I derive a separating equilibrium, where the firm with a better type project willingly gives up valuable financial flexibility by doing straight debt financing, while bad type firms issue non-recourse debt.

At this stage, I consider extending the model to analyze contingent limited recourse debt. While the preliminary results show that the main intuition remains unchanged, separating with a contingent or limited in amount recourse claim might provide a more efficient signal of the quality of the initial project than the issue of straight full recourse debt considered in the equilibrium of the current model.

## Appendix

*Proposition 3.1: Signaling under debt financing is more efficient than under equity financing*

*Proof:* Consider the firm raising  $w$  funds from outside investors. If the firm can issue enough riskless debt, the proof is trivial, since financing with riskless debt does not entail any adverse selection costs.

Next, consider the risky debt issuance. I will show that the efficient equilibrium separating signaling cost for equity financing is higher than for debt financing. Using *Result 3* and notation  $\Delta^{\text{EQUITY}}$  for signaling cost with equity financing and  $\Delta^{\text{DEBT}}$  for signaling cost with debt financing:

$$\Delta^{\text{EQUITY}}(w) - \Delta^{\text{DEBT}}(w) = w [1 - (p_b(h-l) + l)/(p_g(h-l) + l)] - (w-l)(1 - p_b/p_g)$$

Rearranging the terms:

$$\begin{aligned} \Delta^{\text{EQUITY}}(w) - \Delta^{\text{DEBT}}(w) &= l((p_g - p_b)/p_b) + w(p_b/p_g - (p_b(h-l) + l)/(p_g(h-l) + l)) \\ &= l((p_g - p_b)/p_b) + w l((p_g - p_b)/(p_g(p_g(h-l) + l))) \\ &= l(p_g - p_b)/p_g [1 - w/(p_g(h-l) + l)]. \end{aligned}$$

Since the project has a positive NPV, the term in the brackets is positive, and

$$\Delta^{\text{EQUITY}}(w) > \Delta^{\text{DEBT}}(w). \diamond$$

Result 3: Here I derive the signaling equilibrium for the setting of Section 3 under equity financing at  $t = 1$ .

For the model outlined in Section 3, assume now that the firm of type  $\theta$  attempts to raise  $w$  from outside investors by selling off a fraction  $\alpha_\theta$  of the firm's equity. Again, I assume that the project is profitable enough that both types of the firms choose to participate in the investment. Let "a" denote the action of the firm, where  $a = 1$  denotes costly signaling and  $a = 0$  denotes no signaling. Outside investors expect to break even, given their beliefs about the firm upon observing the action  $a$ ,  $\theta(a)$ :  $\theta(1) = g$ ,  $\theta(0) = b$ . The contract space is  $\{\alpha_b, \alpha_g\}$ , where  $\alpha_b > \alpha_g$ . Then, following the discussion in Section 3, incentive compatibility constraints are given by:

$$\begin{aligned} (1 - \alpha_b)(p_b(h-l) + l) &> (1 - \alpha_g)(p_b(h-l) + l) - \Delta, \\ (1 - \alpha_b)(p_g(h-l) + l) &\leq (1 - \alpha_g)(p_g(h-l) + l) - \Delta, \end{aligned}$$

where  $(p_b(h-l) + l)$  is the payoff of the bad type's project, and  $(p_g(h-l) + l)$  is the payoff of the good type's project. Collecting terms, we obtain:

$$\begin{aligned} \Delta &< (\alpha_b - \alpha_g)(p_b(h-l) + l) \\ \Delta &\geq (\alpha_g - \alpha_b)(p_g(h-l) + l), \end{aligned}$$

with the inequality holding for the most efficient signaling level.

The investor's zero-profit constraint is:

$$w = \alpha_\theta(p_\theta(h-l) + l),$$

so that  $\alpha_g = w/(p_g(h-l) + l)$ , and  $\alpha_b = w/(p_b(h-l) + l)$

and

$$\Delta^E(w) = w [1 - (p_b(h-l) + l)/(p_g(h-l) + l)]. \diamond$$

The intuition behind this equilibrium is as follows. Although the expected cost of the signal is the same for both types, the expected benefits from signaling are higher for the better type: while the fraction of the profits that either type gets to retain, as the result of the signaling, is the same, profits are higher for the better type, making its expected benefit of the signaling higher.

*Result 4.1: In the setting of Section 4.1, the expected success of projects coming at  $t=0$  and  $t=1$  is positively correlated for  $(\rho^H - \rho^L) > 0$  and negatively correlated for  $(\rho^H - \rho^L) < 0$ .*

*Proof:* Upon observing realization of the cash-flow at  $t=1$  from Project 1, the conditional probability of Project 2 succeeding at date  $t=2$ , expected by uninformed parties is:

$$\rho^H p_g + (1 - \rho^H) p_b = P_{Hh},$$

where  $\rho^H$  is the expected fraction of good type projects in the market at  $t=1$  given the success of Project 1, and

$$\rho^L p_g + (1 - \rho^L) p_b = P_{Lh},$$

where  $\rho^L$  is the expected fraction of good type projects in the market at  $t=1$  given the failure of Project 1.

Similarly, the expected probability of Project 2 failing (realizing cash flow  $l$ ) at  $t=2$  is:

$$\rho^H (1 - p_g) + (1 - \rho^H) (1 - p_b) = P_{Hl},$$

where  $\rho^H$  is the expected fraction of good type projects in the market at  $t=1$  given the success of Project 1, and

$$\rho^L (1 - p_g) + (1 - \rho^L) (1 - p_b) = P_{Ll},$$

where  $\rho^L$  is the expected fraction of good type projects in the market at  $t=1$  given the failure of Project 1.

Then  $P_{Hh} - P_{Lh} = (p_g - p_b) (\rho^H - \rho^L)$ , and  $P_{Hl} - P_{Ll} = (p_g - p_b) (\rho^L - \rho^H)$ .

Therefore for  $\rho^H > \rho^L$ , projects exhibit cyclicity ( $P_{Hh} > P_{Lh}$ ) and ( $P_{Hl} < P_{Ll}$ ).

For  $\rho^L > \rho^H$ , projects exhibit countercyclicity ( $P_{Hh} < P_{Lh}$ ) and ( $P_{Hl} > P_{Ll}$ ).  $\diamond$

*Result 4.2.1: In the setting of Section 4.2, expected asymmetric information is positively correlated across dates for  $(\rho^H - \rho^L) > 0$  and negatively correlated for  $(\rho^H - \rho^L) < 0$ .*

*Proof:* At  $t=0$ , the expected probability of obtaining positive private information (information that the project is good) at  $t=1$  is:

$$\begin{aligned} q_G \rho^H + (1 - q_G) \rho^L &= P_{Gg} && \text{for a firm with Good type period 1 project, and} \\ q_B \rho^H + (1 - q_B) \rho^L &= P_{Bg} && \text{for a firm with Bad type period 1 project.} \end{aligned}$$

Correspondingly, expected probability at  $t=0$  of obtaining bad private information at  $t=1$  is:

$$\begin{aligned} q_G (1 - \rho^H) + (1 - q_G) (1 - \rho^L) &= P_{Gb} && \text{for firm with Good type period 1 project, and} \\ q_B (1 - \rho^H) + (1 - q_B) (1 - \rho^L) &= P_{Bb} && \text{for firm with Bad type period 1 project.} \end{aligned}$$

Now it is easy to see that:

$$\begin{aligned} P_{Gg} - P_{Bg} &= (q_G - q_B) (\rho^H - \rho^L), \text{ and} \\ P_{Gb} - P_{Bb} &= (q_G - q_B) (\rho^L - \rho^H). \end{aligned}$$

Thus,  $P_{Gg} > P_{Bg}$  and  $P_{Gb} < P_{Bb}$  (positive expected asymmetric information correlation) for  $\rho^H < \rho^L$ , and  $P_{Gg} < P_{Bg}$  and  $P_{Gb} > P_{Bb}$  (negative expected information correlation) for  $\rho^H > \rho^L$ .  $\diamond$

*Result 4.2.2:* Here I derive expressions for the face value of the debt claims for the separating equilibrium of Section 4.2.

Since investors at least expect to break even, the face value of the debt claim for type  $\theta$  has to satisfy the following constraints:

$$I = q(\theta) F(\theta) + (1 - q(\theta))Z,$$

where, as in Section 4.1,

$$Z = \begin{cases} L + (F(\theta) - L), & \text{for straight debt} \\ L, & \text{for non-recourse project finance debt} \end{cases}$$

For the set of the market beliefs in the signaling equilibrium of Section 4.2, we have the following:

$$F = \begin{cases} I, & \text{for straight debt} \\ (I - L)/q_B + L, & \text{for non-recourse debt. } \diamond \end{cases}$$

*Result 5:* (Alternative signaling instrument.) In the present model, assumption that signaling is achieved through money burning is intended partially to simplify the analysis. A more practical

(and more plausible) signaling instrument could be some non-dissipative action, for example a pledge of collateral.

Consider a signaling equilibrium analogous to the one discussed in Section 3.1 but with the use of collateral as a signaling instrument. Then, following the discussion in Section 3.1, in such a signaling equilibrium, the payoffs to the firms depending on their type (either “g” or “b”) and on their action (denoted by a superscript  $\Delta$  if they commit to pledge collateral  $\Delta$ ) are:

$$\pi_g^\Delta = p_g (h - f_g) - (1 - p_g) \Delta$$

$$\pi_g = p_g (h - f_b)$$

$$\pi_b^\Delta = p_b (h - f_g) - (1 - p_b) \Delta$$

$$\pi_b = p_b (h - f_b)$$

For the signaling equilibrium to exist, incentive compatibility constraints must be satisfied, meaning that there must exist a  $\Delta$ , for which  $\pi_g^\Delta > \pi_g$  and  $\pi_b^\Delta \leq \pi_b$ , with the equality holding for the most efficient signal level:

$$p_b (h - f_b) \geq p_b (h - f_g) - (1 - p_b) \Delta$$

$$p_g (h - f_b) < p_g (h - f_g) - (1 - p_g) \Delta$$

The first constraint above requires that the payoff to the bad type firm if he mimics the good type will be no higher than his payoff if he does not mimic and the second constraint requires that the payoff to the good type if he signals is higher than his payoff if he does not.

Therefore, the signal level should satisfy:

$$\Delta \geq p_b (f_b - f_g) / (1 - p_b)$$

$$\Delta < p_g (f_b - f_g) / (1 - p_g)$$

A separating equilibrium must also guarantee the creditor nonnegative expected profit; in fact the creditor earns zero profit on each contract under the assumption of a competitive market for the firm’s claims. Thus, if the firm raises  $w$  funds, the creditor’s zero-profit constraints are:

$$p_g f_g + (1 - p_g) (l + \Delta) = w$$

$$p_b f_b + (1 - p_b) (l + \Delta) = w.$$

Solving these equations for face values  $f_b$  and  $f_g$  and substituting into the incentive compatibility constraints above yields:

$$\Delta^{\text{COLLATERAL}} = (w - l) (p_g - p_b) / [p_g - p_b - p_g(1 - p_b)].$$

The intuition behind this equilibrium is the following. The expected cost of pledging the same amount of collateral is smaller for the good type. The cost (loosing collateral) is realized only in the  $l$ -state and the probability of reaching that state is strictly lower for the good type. On the other hand, the expected benefit from pledging collateral and getting a debt contract with a lower face value as a result, is higher for the good type than for the bad one. Indeed, since the benefits of having to pay out a lower face value are realized only in the solvent  $h$ -state of the risky project, the expected benefit from signaling directly proportional to the probability of reaching  $h$ -state, which is strictly higher for the good type.

Notice that all the results of the paper go through with the signaling schedule described above.

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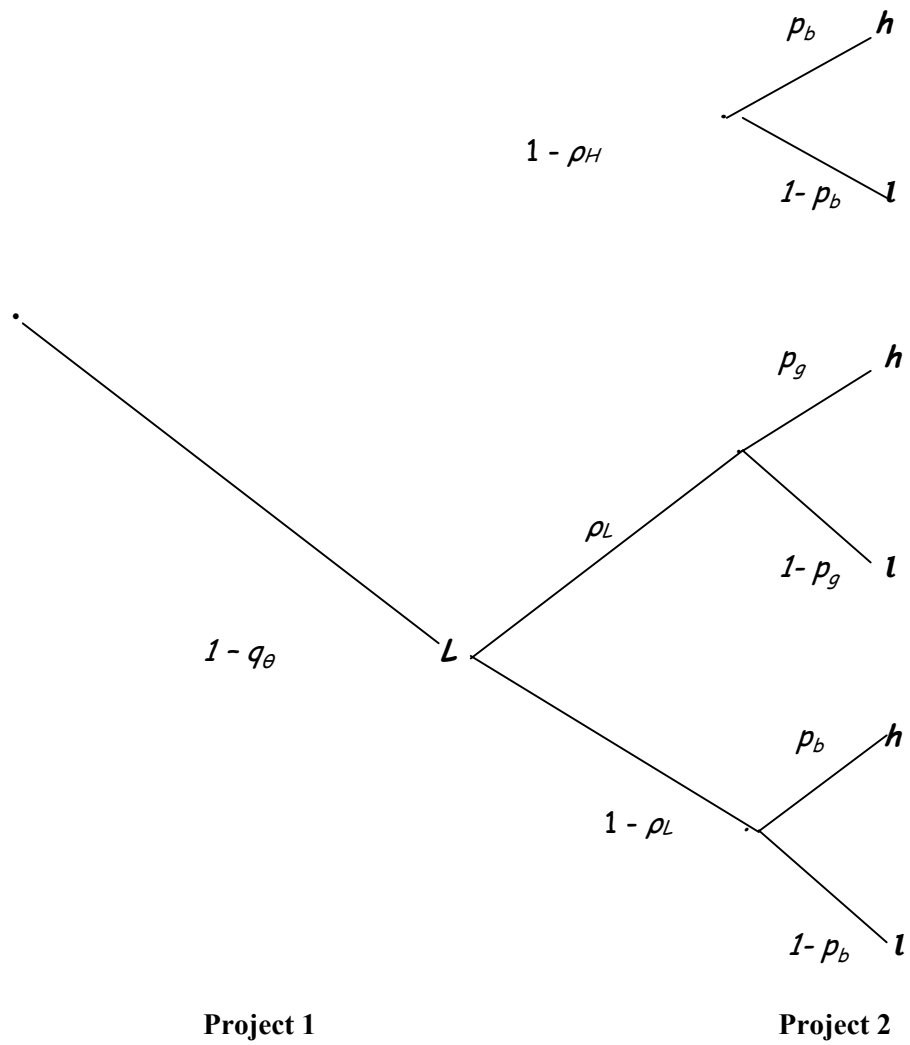
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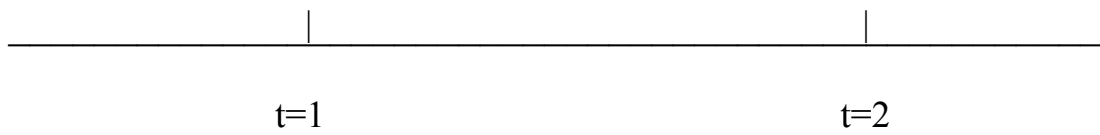
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**Figure 2**



- Firm type is revealed

- Firm receives cash flows

to the manager	from the project
- Manager chooses debt contract	- Claims are settled
- Firm issues debt claims	- Firm is liquidated
- Investors buy claims at market price	

## End Notes

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<sup>1</sup> The term project finance is often misused: notice the difference between project finance and financing *any* project.

<sup>2</sup> It is essential to point out the difference between “off-balance sheet” financing and no recourse/no liability financing. In this paper I am not focusing on any financial implications of project finance being an off-balance sheet activity but treat recourse feature as including any obligations of the sponsor with respect to the project, whether reported on the balance sheet or not.

<sup>3</sup> By way of comparison with other financing mechanisms in the United States in 1998, the global project finance market is smaller than the \$280 billion municipal bond market, the \$198 billion

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asset backed security market, and the \$207 billion equipment leasing market, but substantially larger than the \$35 billion initial public offering (IPO) market and the \$19.2 billion venture capital market (all figures are for 1998.) Recent examples of project finance transactions include the \$16 billion Channel Tunnel connecting France and the United Kingdom, the \$5 billion Iridium global satellite project, and the \$4 billion oil and gas refinery in Venezuela known as SINCOR.

<sup>4</sup> The results of the study can be extended to explain the optimality of limited recourse or “structured” debt claims. Also, notice that while a risk reduction argument can be also used to explain the use of such financing instruments, the framework of the current model can explain the optimality of different forms and degrees of recourse and balance sheet support, even under the assumption of risk neutrality for the firm.

<sup>5</sup> The role of the liability form as a signaling device has been addressed by Chamley (1983). In a different framework, he studies a model of occupational choice (entrepreneurs, employees), with asymmetric information in loan markets about the abilities of entrepreneurs.

<sup>6</sup> See for example, Lewellen (1971), Higgins and Schall (1975), Kim and McConnell (1977).

<sup>7</sup> Several other papers focus on different aspects of optimal debt financing under asymmetric information: relative seniority of the claims of existing debtholders vis-à-vis present and future security holders (Berkovitch and Kim(1990)), debt-maturity decisions (Goswami, Noe, Rebelo (1995)), optimality of debt security backed by the pool of the assets vs. separate debt claims on the separate assets (DeMarzo (1997)).

<sup>8</sup> The assumption that the manager faces uncertainty about the quality of the future project at the date of initial financing decision,  $t=0$ , is a crucial element of the model.

<sup>9</sup> If the available financing opportunities include issuing equity claims, then the informational problems are similar to those of issuing risky debt, which we study here.

<sup>10</sup> My setting, therefore, is similar to the one in Merton and Bodie (1992) where the analysis is focused on the guarantee by the parent company with sufficiently large assets to meet the project debt obligations, therefore making the parent guarantee riskless. This does not apply to the situation when a firm has worse credit rating than the project itself or does not have assets-in-place sufficient for financing the project.

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<sup>11</sup> In the setting of the model, issuing non-recourse debt is equivalent to separate incorporation of projects coming at  $t=0$  and  $t=1$  into two stand-alone corporate entities, each with the liability restricted to the cash flows or assets of the particular entity. On the other hand, a full recourse claim on Project 1 is similar to joint incorporation, where the individual project's limited liability constraint is somewhat weakened, since the firm cannot simply default and walk away from obligations on the first project without a loss of value (in the model the loss of value would be the inability to undertake the second project.)

<sup>12</sup> This amounts to assuming  $i > l+(H-I)$ . Thus the analysis is relevant for firms with sufficiently high future investment needs.

<sup>13</sup> There is an extensive literature that examines how financial decisions provide information to market participants. The financial decisions analyzed include dividend policy [John and Williams (1985) and Ambarish, John and Williams (1987)], the scale of investment [Krasker (1986)], etc. An example of the model with advertisement as a money-burning signal is presented in Milgrom and Roberts (1986).

<sup>14</sup> See, for example, Mas-Colell, A., M.D. Whinston, and J.R. Green (1995), *Microeconomic Theory*, Oxford University Press

<sup>15</sup> Notice that  $fg < fb$  in the fully revealing equilibrium.

<sup>16</sup> For the signaling equilibrium with debt to obtain, the signal has to be costly for the firm in all states - whether the project succeeds or fails. One possibility for such a signaling cost would be a nonpecuniary cost similar to the one considered in Diamond (1984). The precommitment to costly signal might be seen, for example, as a precommitment to the contract restricting manager's private benefits. A more practical (and more plausible) signaling instrument could be a pledge of collateral. See *Result 5* in Appendix for discussion of alternative signaling instrument.

<sup>17</sup> Since external financing is more expensive than internal, the firm always ploughs earnings from the first project into the second period investment.

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<sup>18</sup> Modifying assumptions to allow for the first period type dependent conditional distribution of private information at  $t=1$ , namely for  $p_G^S \neq p_B^S$  would not change the conclusion or the intuition of the model while complicating the analysis.

<sup>19</sup> If the straight claim were risky, the issue of nonrecourse claim, under these parameters, would only signal Bad quality. Thus, even under a more general model, both types of firms pool at the straight debt claim for  $p^L < p^H$ .

<sup>20</sup> Notice that another possible interpretation of the results of the section is that the firm can use the choice of non-recourse debt financing of the current project to signal the higher quality of its future investment opportunities. I would like to thank Archishman Chakraborty for suggesting this explanation.