THE DESIGN OF DEBT CONTRACTS

by

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1. Introduction

From the seminal work of Modigliani and Miller (1958) we know that in perfect capital markets the value of a firm is not affected by its choice of financial structure. This implies that the design of the contractual features of the specific securities which the firm issues to raise capital is irrelevant. More generally, it also implies that the identity of the counterpart to the transaction, whether it be a financial institution or anonymous traders in the financial markets, is irrelevant.

This picture changes dramatically when the firm and investors operate under conditions of asymmetric information. The presence of informational asymmetries impairs a firm's ability to raise capital because it makes it more difficult to design financial contracts that protect both firms and investors from opportunistic behavior.

Asymmetric information can originate in several different circumstances. To fix ideas, we start by developing a simple framework that will be useful for organizing in a systematic way the models discussed in this chapter. We consider the problem faced by an entrepreneur wishing to raise capital to undertake an investment project. The investment project requires a certain investment I (the size of the investment may either be fixed, or may be chosen optimally by the entrepreneur) and at a later date generates output x. The output level depends on both the selection of an action $a \varepsilon A$ taken by the entrepreneur, and the realization of the future state of the world $\omega \varepsilon \Omega$. The action, a, is a complete description of how the entrepreneur will manage the firm, including the use of the capital raised from investors. The selected action, a, and the state of the world, ω, jointly determine output according to the production function $X(a, \omega)$. Entrepreneurs and investors may be either risk averse or risk neutral, and they all have access to a risk-free technology yielding a rate of return $r \geq 0$.

In our most basic setting, entrepreneurs and investors interact over a single time period (see the timeline in Figure 1). This basic setting can be easily extended into a dynamic framework in which the one-period model is repeated over time. At the beginning of the period, $t = 0$, the entrepreneur, who may have an initial wealth W_0, seeks financing from a number $n \geq 1$ of investors. Funds are raised via a contractual agreement that will specify the conditions under which financing takes place, including the amount of capital contributed by investors, the rules for sharing future payoffs, and, possibly, restrictions on the entrepreneur's behavior during the period spanned by the contractual agreement. Before the contract is negotiated (and finalized), the entrepreneur may have access to information that is relevant for the determination of the value of the securities issued by him, and therefore for their fair pricing. We model this pre-contractual information by assuming that the entrepreneur observes the realization of a random variable $\theta \varepsilon \Theta$, which we can interpret as a "signal" on the future state of the world ω. The parameter θ

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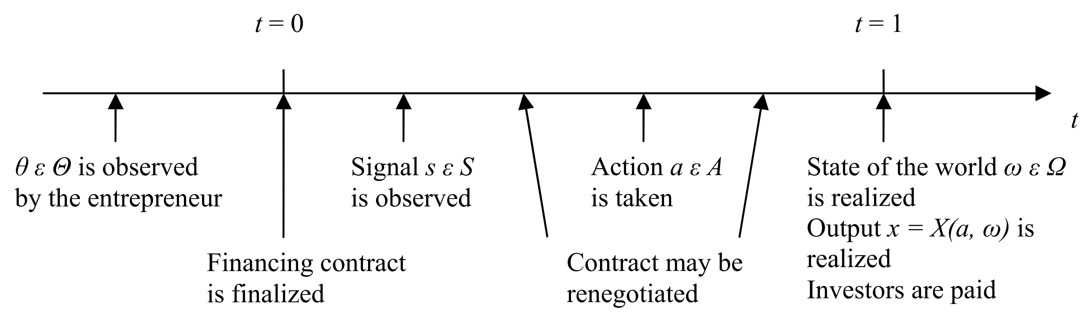
identifies the entrepreneur's "type." The entrepreneur's ability to obtain this pre-contractual private information places investors at an information disadvantage and exposes them to adverse selection.

After the entrepreneur and investors finalize the contract (that is, after the securities are "sold" to the investors), and before the action $a \varepsilon A$ is taken, the entrepreneur may observe a second signal $s \varepsilon S$. This signal s may be publicly observable, or it may be observed privately by the entrepreneur. Following the observation of the signal, the entrepreneur and investors may wish to renegotiate their original contract.

Figure 1



Once renegotiation is completed, the entrepreneur chooses the action $a \varepsilon A$ which will contribute to the determination of the final output x. The choice of the action a may include the determination of the amount of capital that is invested in the technology, I, as well as any other action that is relevant for the entrepreneur and investors. This action may either be observable by everyone, or it may be carried out privately by the entrepreneur, exposing the investors to moral hazard.

After the action a is chosen, a second round of contract renegotiations may take place. Finally, the state of the world $\omega \varepsilon \Omega$ is realized, and output x is determined according to the production function $X(a, \omega)$. At this point, the entrepreneur must allocate a part, y, of the output to investors as a reward for their investment. The distribution of output to investors will be determined on the basis of the contractual agreement established at the outset and possibly modified at the interim renegotiation stages. This distribution may be impaired by the fact that outside investors may observe the realization of output x only after paying a certain verification cost, k_I. After the verification cost is paid, output may be publicly observed, or it may be observed privately only by the investor who paid it. We characterize these situations as those of costly state verification, *CSV*.

The entrepreneur's problem at the outset of the game is to design contracts that allow him to pursue efficiently all profitable investment opportunities. If capital markets are perfect, and thus no information problem exists, entrepreneurs and investors are always able to write optimal contracts that lead to efficient outcomes. In this case, assuming that financial markets are perfectly competitive, the entrepreneur will offer a contract that maximizes his own expected utility, $EU(\theta, a, \omega, \ldots)$, subject to appropriate individual rationality constraints for investors. The presence of information asymmetries may impair optimal contracting either because of the possibility of pre-contractual information (adverse selection), or because the entrepreneur can privately take payoff-relevant actions (moral hazard), or because the final output may be observed by outsiders only at a cost (*CSV*). Thus, the presence of these informational asymmetries impairs the entrepreneur's ability to write contracts with investors and may result in inefficient outcomes.

Note that the entrepreneur's ability to enter into contracts with investors is also impaired in situations in which relevant variables (such as the intermediate signal s, the entrepreneurial action a, and the final output x, among others) are observable by both the entrepreneur and investors, but not by third parties in charge of enforcing contracts. In this case, contracts contingent on such variables are not enforceable in a court of law. We will refer to these situations as those of observability but non-contractibility.

In the situation described above, the entrepreneur may want to write contracts that reduce the adverse impact of information asymmetries, improving his payoff. In this chapter we will discuss the circumstances in which debt contracts emerge endogenously as optimal contracts. We will also discuss how the inclusion of additional contractual features, such as seniority, maturity, and collateral, may be used by the entrepreneur and investors to mitigate the adverse impact of information asymmetries.

In this chapter we will take a relatively narrow approach and focus explicitly on debt contracts as optimal securities. Thus, we will have only an incidental discussion of the instances in which other securities may emerge from an optimal security design problem. Notably, we will not discuss the case of equity contracts as optimal securities (see, for example Myers, 2000, and Fluck, 1998 and 1999, among many others), and the optimal security design problem in the context of incomplete markets and symmetric information (see, for example, Allen and Gale, 1988). We will also not discuss the optimal combination of debt with other securities, such as equity, to determine the optimal financial structure of the entrepreneur's venture. For excellent reviews of optimal financial contracting, see Allen and Winton (1995) and Harris and Raviv (1991) and (1992).

2. Debt contracts and costly state verification

The primary aim of this chapter is to determine under what circumstances a security having the characteristics of the standard debt contract emerges, in equilibrium, as an optimal security. One of the first papers addressing this issue is Townsend (1979). In this paper, a risk-averse entrepreneur endowed with a risky technology seeks financing from a single investor. The entrepreneur and the investor care only about end-of-period wealth. Information is asymmetric in that the output of the technology, x, may be observed at no cost only by the entrepreneur, while it can be observed by the investor only after paying a state-dependent verification cost, $k_1(x)$. Thus, the model is of the *CSV* type.

In this setting, a contract is a pair of functions $\{y(x), v(x)\}$ specifying the state-dependent payment $y(x)$ made by the entrepreneur to the investor, and the state-dependent verification policy $v(x)$, with $v(x) = 1$ if verification occurs and $v(x) = 0$ if no verification occurs. Townsend (1979) shows that if the investor is risk neutral and the verification costs are constant, $k_1(x) = k_1$ for all x, the optimal contract is such that,

a) verification occurs only in the "bad" states, that is, $v(x) = 1$ for $x < \underline{x}$, for a certain threshold level $\underline{x}$;
b) in the states without verification, $v(x) = 0$, the entrepreneur pays the investor a predetermined fixed amount F; and

c) in the states with verification, $v(x) = 1$, the predetermined state-dependent amount $y(x)$ paid by the entrepreneur to the investor has the property that $y(x) + k_1 < F$.

Thus, optimal contracts have the debt-like features that no verification occurs when the entrepreneur makes a certain fixed pre-specified payment, and state verification occurs only in the "bad states," that is, when the entrepreneur's output x is below a certain predetermined threshold $\underline{x}$. The intuition is as follows. First, incentive compatibility requires that if no verification occurs, the entrepreneur makes a constant payment, F. In addition, if verification occurs, incentive compatibility requires that the payment $y(x)$ must be smaller than in the non-verification states, $y(x) \leq F$. Finally, because of entrepreneurial risk aversion, the optimal contract calls for some risk sharing and, thus, allows the entrepreneur to make the smaller payments in states in which output is lower. This implies that in the states of the world in which verification occurs, which we can interpret as "bankruptcy" states, the optimal sharing rule between entrepreneurs and investors will typically allow the entrepreneur to keep some of the firm's output for personal consumption. Therefore, the optimal contract has the property that the investor will not recover all possible output under bankruptcy and, rather, allows for some debt forgiveness.

Gale and Hellwig (1985) consider a risk-neutral entrepreneur seeking financing from a single investor. The assumption that the entrepreneur is risk neutral allows for the derivation of the standard debt contract as the outcome of an explicit optimal security design problem. The paper also adopts a *CSV* framework and assumes that while the entrepreneur observes output x at no cost, the investor can observe output only at a cost, $k_1(\omega, I)$, which may depend on both the state of the world ω and the investment level, I. In addition, if verification occurs, the entrepreneur will suffer a certain non-pecuniary (fixed) cost k_0.

In this setting a contract is a 4-tuple $\{ I, K, y(\omega), v(\omega) \}$ specifying the investment made in the technology, I, the amount contributed by the investor, K, the repayment schedule (net of verification costs) to the investor, $y(\omega)$, and the verification schedule, $v(\omega)$, contingent on the realization of the state of the world $\omega \, \varepsilon \, \Omega$. By using the revelation principle (see Myerson, 1979, and Harris and Townsend, 1981), the optimal contract is determined by the program

$$\begin{aligned} \max \quad & E[X(\omega, I) + (1 + r)(W_0 + K - I) - y(\omega) - (k_0 + k_1)v(\omega)] \\ \text{s.t.} \quad & \text{i)} \quad Ey(\omega) \geq (1 + r)K \\ & \text{ii)} \quad y(\omega) \leq X(\omega, I) - k_1 v(\omega) + (1 + r)(W_0 + K - I) \\ & \text{iii)} \quad \omega \in \operatorname{argmax}_{\sigma} \; X(\omega, I) + (1 + r)(W_0 + K - I) - y(\sigma) - k_1 v(\sigma) \\ & \text{iv)} \quad I \geq 0, \quad K \leq I \leq K + W_0. \end{aligned} \tag{1.1}$$

The optimal contract solving Problem (1.1) maximizes the entrepreneur's expected utility subject to (i) the investor's individual rationality constraint, (ii) the end-of-period feasibility constraint, (iii) the incentive compatibility constraint (that is, the "truth-telling" constraint), and (iv) the non-negativity and investment feasibility constraints. The optimal contract solving (1.1) has the following properties:

a) *maximum equity participation:* it requires the entrepreneur to contribute all his wealth, $I = K + W_0$;
b) *fixed repayment*: $y(\omega) = F$, for some $F > 0$ whenever the state of the world is not verified, $v(\omega) = 0$;
c) *bankruptcy decision*: the state of the world is verified whenever $x < F$;

d) *maximum recovery:* if verification occurs, $v(\omega) = 1$, investors recover all that is left after the verification costs are paid: $y(\omega) = X(\omega, I) - k_1$.

Thus, the optimal security is a *standard debt contract with maximum equity participation*.

It is interesting to compare the level of investment characterized in Problem (1.1) with the first-best investment that is obtained in absence of verification costs (that is, when $k_1 = k_0 = 0$). Gale and Hellwig (1985) show that, if the state of the world is verified with a positive probability when the firm invests at the first-best level and if verification costs are strictly positive in those states, then the level of investment specified in the optimal contract that solves (1.1) is strictly lower than the first-best level. This means that the presence of bankruptcy costs leads to *underinvestment*.

A feature of the Gale and Hellwig model is that verification (bankruptcy) costs paid by the entrepreneur, k_0, are exogenously given. Diamond (1984) considers a model similar to the one in Gale and Hellwig (1985), but in which the bankruptcy costs are derived endogenously as part of the optimal contract. In this model, risk-neutral entrepreneurs seek financing from investors for an investment project. Each project now requires a unit investment, $K = I = 1$, which is provided by the participation of n different investors. The project's output, $x = \omega$, can be observed only by the entrepreneur, and no verification technology is available to outside investors. Thus, strictly speaking, the model is again cast in a *CSV* setting, with "prohibitively large" investors' verification costs, k_1. The absence of a (viable) verification technology implies that investors receive a payment only if the entrepreneur has the incentive to do so. The entrepreneur's incentive to reward investors for their investment depends on a non-pecuniary penalty k_0 that may be imposed on him. In contrast to Gale and Hellwig's model, here the penalty k_0 is chosen endogenously as an integral part of the optimal contract.

In Diamond's setting an optimal contract is a pair $\{y(x), k_0(y)\}$ specifying the payment $y(x)$ that the entrepreneur makes to the investors, given the realized output, x, and the non-pecuniary penalty, $k_0(y)$, imposed on the entrepreneur as a function of the payment he makes to investors. The optimal contract $\{y(x), k_0(y)\}$ satisfies,

$$\begin{aligned}
&\max_{k_0, y} \; E_x\{ \max_{y \in [0, x]} x - y - k_0(y) \} \\
&\text{s.t.} \quad \text{i)} \; y \in \arg\max_{y \in [0, x]} x - y - k_0(y), \\
&\qquad\quad \text{ii)} \; E_x\{\arg\max_{y \in [0, x]} x - y - k_0(y)\} \geq 1 + r,
\end{aligned} \tag{1.2}$$

where (i) is the incentive compatibility constraint and (ii) is the investor's individual rationality constraint. The optimal contract has the properties that

a) $y(x) = \min\{x, F\}$, where F is the smallest solution to

$$\Pr\{x<F\} \times E_x\{x \mid x < F\} + F \times \Pr\{x \geq F\} = 1 + r; \tag{1.3}$$

b) $k_0(y) = \min\{F - y, 0\}$.

Thus, the optimal contract is a standard debt contract with maximum recovery. Note that the optimal contract requires that the entrepreneur not suffer any penalty if he pays investors the fixed payment F. The contractual penalty $k_0(y)$ is optimally set to give the entrepreneur the incentives to pay all the output to the investors, to minimize the penalty. Note also that, under the optimal contract, the entrepreneur will be in default in the states in which $x < F$, and he will suffer the non-pecuniary costs $F - x$. Thus, the optimal contract is costly.

a. Multi-period contracts

The previous models explain debt-like features of optimal contracts in a static one-period framework. Chang (1990) examines a two-period extension of the basic Townsend model. In Chang's model the entrepreneur makes the initial investment I in a technology which now generates an output both at $t = 1$, denoted x_1, and at a later date $t = 2$, denoted x_2. Output at each date is observable by the outside investor only after paying a verification cost $k_t(x_t)$, $t = 1,2$. Both the entrepreneur and the investor are risk neutral. Chang shows that the optimal contract involves the entrepreneur making a payment to the investor at both dates, with verification occurring at each date $t = 1,2$ only if output level, x_t, falls below a certain critical level $\overline{x_t}$. Furthermore, the optimal contract gives the entrepreneur the option to make a larger payment at the first date (if the first-period output is high) in order to reduce the residual payment at the second date. In addition, it is optimal to restrict the entrepreneur's ability at the first date either to make payments to himself or to borrow additional funds. These properties imply that the optimal contract is again a debt contract requiring interim payments (which can be interpreted as coupons or a sinking fund provision), with features like call (pre-payment) provisions and covenants restricting the borrower's ability to pay interim dividends and to incur additional debt.

In a similar spirit, Chang (2005) examines the infinite-horizon version of the basic Townsend (1979) model, in which the entrepreneur is risk averse and the investor is risk neutral. If output is not storable and if the entrepreneur has no other access to credit markets, the contract with the investor is the only vehicle available to the entrepreneur for intertemporal consumption smoothing. This implies that the intertemporal dimension weakens the entrepreneur's incentive compatibility condition and, thus, makes it easier for the investor to extract payments from the entrepreneur, reducing the need for monitoring.

b. Stochastic monitoring

The original Townsend (1979) paper suggests that optimal contracts may also include stochastic verification policies (rather than the simple deterministic ones discussed above) whereby the threat of verification is sufficient to induce honesty from the entrepreneur, thus reducing the expected verification costs. This possibility is further explored by Border and Sobel (1987). Their study shows that if both the entrepreneur and the investor are risk neutral, in the case of stochastic monitoring, payments by the entrepreneur to the investor, $y(x)$, are monotonically increasing in output x, while the verification probability, $p(x)$, is a decreasing function of output x. Thus, with stochastic monitoring, payments and verification probability have the same "flavor" as the standard debt contract obtained in a deterministic verification setting in that entrepreneurs pay more to the investor in the "better" states, and investors increase the monitoring probability in the "worse" states.

A critical assumption of Border and Sobel's (1987) is that investor and entrepreneur are both risk neutral. Risk aversion complicates optimal contracts for two reasons: First, it invites risk sharing among agents (creating essential interdependencies among agents); second, it makes verification costly because, as discussed above, the probability of monitoring is greater in the "bad states," in which output is lower, that is, in the states that are of greatest concern to risk-averse agents. These observations open the question of whether the monotonicity properties of Border and Sobel survive under risk aversion.

The role of risk aversion in optimal contracts is explored by Mookherjee and Png (1989). Their paper shows that deterministic verification policies are in general not optimal even under risk aversion, and that entrepreneurial risk aversion may lead to optimal contracts in which the entrepreneur's consumption is not necessarily a monotonic function of the firm's output. Krasa and Villamil (1994) and Winton (1995) extend Townsend's and Border and Sobel's results to the case in which both the entrepreneur and the investor are risk averse. These studies show that optimal contracts have the properties that the payments from the entrepreneur to the investor (weakly) increase with the firm's output x, that is, $y'(x) \geq 0$, and the monitoring probability $p(x)$ decreases with the realization of output, x.

Furthermore, Boyd and Smith (1994) show that, in a risk-neutral setting, with stochastic monitoring, the optimal contract does not look like a standard debt contract anymore because it involves defaults and debt forgiveness also in states in which the entrepreneur is fully able to pay the investor. After calibrating the model, they also argue that with plausible assumptions on key parameters the welfare losses from using standard debt contracts are minimal. They conclude that this small welfare loss helps to explain the wide use of standard debt contracts even in the presence of bankruptcy costs.

Finally, Boyd and Smith (1999) show that if the entrepreneur has access to two (risky) technologies, one (superior) technology that generates unverifiable returns, and another (inferior) that generates verifiable returns, the optimal contract is characterized by a mixture of debt and outside equity. In this setting, investment in the inferior technology with verifiable returns is financed by equity, and allows the entrepreneur to smooth the future income stream. In the optimal contract, equity holders receive low payments in the bad states and are compensated by greater payments in the good states. In the bad states, the technology with verifiable output can generate some liquidity that the entrepreneur can use to repay the debt used to finance the superior technology with non-verifiable output, reducing the expected verification costs.

3. Debt contracts and the allocation of control rights

In the *CSV* models discussed in the previous section, the entrepreneur is induced to repay investors either because investors can pay a verification cost and directly observe output, or because the entrepreneur is penalized if the payment to investors falls short of a certain predetermined amount. In Hart and Moore (1989) and (1998), and Bolton and Scharfstein (1990) the penalty suffered by the entrepreneur in case of default is modeled explicitly in the form of the loss of control over the use of assets. The loss of control gives the entrepreneur the incentive to pay back investors, if he has sufficient wealth to do so. Thus, these models are essentially dynamic in that the entrepreneur makes the required payments to investors in order to enjoy future rents that he can obtain only by maintaining control of the assets. Giving investors the control rights over a firm's assets upon default (with the possible outcome of inefficient liquidation) allows investors sufficient power to extract payments from the entrepreneur. Hence, control rights become a critical feature of the debt contract.

In Bolton and Scharfstein (1990) the entrepreneur has no wealth and is endowed with a technology lasting for two periods. In each period, the technology requires a fixed investment I and generates a level of output $x_t \, \varepsilon \, \{\underline{x}, \bar{x}\}$, with $\underline{x} < \bar{x}$. The smaller output, $\underline{x}$, is contractible and is obtained with probability π; the larger output, $\bar{x}$, is observable but non-contractible and is obtained with probability $1-\pi$. It is assumed that $\underline{x} < I$, that $\bar{\bar{x}} = \pi\,\underline{x} + (1-\pi)\,\bar{x} > I$, and that assets have no liquidation value. This implies that in a single-period horizon the investor has no means to extract sufficient payments from the entrepreneur (he can extract at most the verifiable cash flow $\underline{x}$) and, thus, that the entrepreneur cannot raise sufficient funds to implement the project. In contrast, in a repeated setting the investor can make the availability of financing at t = 1 contingent on payments made in earlier periods. This allows her to extract greater payments from the entrepreneur.

The optimal contract $\{y_1(x), y_2(x)\}$ is one in which the entrepreneur pays in the second period the contractible output, $\underline{x}$, that is, $y_2(x) = \underline{x}$. In the first period, the entrepreneur pays the investor the lower contractible cash flow $\underline{x}$ when this output level is realized, and the output level expected for the second period, $\bar{\bar{x}}$, when the non-contractible output $\bar{x}$ is realized. Thus, $y_1(\underline{x}) = \underline{x}$, and $y_1(\bar{x}) = \bar{\bar{x}}$, that is, $y_1(x) = min\ (x, F)$ where $F = \bar{\bar{x}}$. Furthermore, if the entrepreneur makes the contractual payment for the first period, F, the investor refinances the entrepreneur by providing sufficient funds for the second-period investment, I; the investor does not refinance the entrepreneur if the low payment $\underline{x}$ is realized (in which case the project is terminated). Given this continuation/termination policy, the payment schedule is incentive compatible. This can be seen by noting that if in the first period the larger output $\bar{x}$ is realized, the entrepreneur is indifferent between (i) paying the investor the lower contractible amount $\underline{x}$, and having a payoff equal to $\bar{x} - \underline{x}$; and (ii) paying the investors the contractual amount of $\bar{\bar{x}}$, and earning a payoff equal to $\bar{x} - \bar{\bar{x}}$ for the first period plus the expected payoff of $\bar{\bar{x}} - \underline{x}$, for the second period. Thus, the optimal contract is a debt contract that requires a fixed payment F, together with a commitment to refinance the entrepreneur if the payment is made, and liquidation otherwise.

In Hart and Moore (1989) and (1998), a risk-neutral entrepreneur is endowed with a production technology that requires a single fixed investment I at $t = 0$ and generates a cash flow x_t at dates $t = 1,2$. After the realization of x_1, the firm's assets can be liquidated at $t = 1$ for a liquidation value $L \leq x_2$; thereafter, the assets liquidation value goes to zero. Funds not returned to investors can be reinvested by the entrepreneur at the rate ρ, with $1 \leq \rho \leq x_2/L$. The quadruple $\{x_1, x_2, L, \rho\}$ is a random variable realized at $t = 1$, and it is observable by both the entrepreneur and the investors but is not contractible. Hence, contracts directly contingent on the realization of these variables are not enforceable.

Because cash flows are not contractible, investors can hope to extract a payment from the entrepreneur only by threatening to liquidate the assets at $t=1$. Thus, investors can extract a payment from the entrepreneur only at $t = 1$ (since after that the assets liquidation value is zero). Hart and Moore consider a contract in which at $t = 0$ investors provide the entrepreneur with financing in the amount of $K = I - W_0 + T$, where $T \geq 0$ represents a transfer over and above what is needed for the project. The amount T is invested by the entrepreneur in a private savings account that cannot be seized by investors. In return, the entrepreneur promises to pay investors F and, if in default, to give investors the right to seize the assets and possibly liquidate the firm. Note that the entrepreneur can, at his discretion, use funds from the saving account (funded by the transfer T) to repay the investor, thus reducing the need for asset liquidation.

Without the right to seize the firm's assets, investors will never be able to extract any payment from the entrepreneur. The maximum payment investors can extract from the entrepreneur, given their right to seize the firm's assets, is determined as follows. At $t = 2$ investors cannot extract any payment because the assets have no liquidation value. By making the payment F at $t = 1$, the entrepreneur maintains control of the firm's assets and secures for himself the right to enjoy the assets' cash flow at $t = 2$. If no payment is made at $t=1$, investors obtain control of the assets, but since liquidation is inefficient, they have an incentive to renegotiate the contract with the entrepreneur. Renegotiation is modeled as follows. With probability α, the entrepreneur makes a "take-it-or-leave-it" offer to investors, where α represents the entrepreneur's bargaining power. Investors have the option to liquidate the asset at a value L and therefore, the entrepreneur must give them at least L. Note that some inefficient liquidations must occur if $T + x_1 < L$. With probability $1 - \alpha$, investors make a take-it-or-leave-it offer to the entrepreneur. Since the entrepreneur can always keep $T + x_1$, which represents his "status-quo" point, investors will be able to extract a payment of $T + x_1 - (T + x_1 - x_2)/\rho$ if the entrepreneur is not cash constrained (i.e., if $T + x_1 \geq x_2$), and to extract a payment of $T + x_1 + [1 - (T + x_1)/x_2]L$ if the entrepreneur is cash constrained (i.e., if $T + x_1 < x_2$), in which case some liquidation inefficiently occurs. Thus, in state (x_1, x_2, L, ρ), investors can at most

$$\overline{F}(x_1,x_2,L,T,\rho) = \alpha L + (1 - \alpha) \min\left\{T + x_1 + \left[1 - \frac{T + x_1}{x_2}\right]L \,;\, T + x_1 - \frac{T + x_1 - x_2}{\rho}\right\} \quad (1.4)$$

and the creditor will receive at most

$$\hat{F} = \min\{\overline{F}; F\}. \quad (1.5)$$

Given (1.4) and (1.5), the payoff to the entrepreneur will be $(x_1 + T - \hat{F})\rho + x_2$ if $x_1 + T > \hat{F}$ (since in this case the entrepreneur is sufficiently liquid to pay investors), and it will be $[1 - (\hat{F} - x_1 - T)/L]\, x_2$ if $x_1 + T \leq \hat{F}$, since in this case the entrepreneur will have to liquidate a fraction of the assets $[1 - (\hat{F} - x_1 - T)/L]$ to make the payment $\hat{F}$. Thus, entrepreneur's payoff is

$$\Pi(x_1, x_2, L, T, \rho) = \min \left\{\left[1 - \frac{\hat{F} - T - x_1}{L}\right]x_2;\; (x_2 + T - \hat{F})\rho\right\}. \quad (1.6)$$

The entrepreneur's problem is then to solve

$$\begin{aligned} &\max_{F,T} \quad E\Pi(x_1,x_2,L,T,\rho) \\ &\text{s.t.} \qquad E\hat{F}(x_1,x_2,L,T,\rho) \;\geq\; I + T - W_0. \end{aligned} \quad (1.7)$$

Examination of (1.5) and (1.6) reveals the distinct roles of F and T in the maximization problem (1.7). An increase in F decreases the entrepreneur's payoff in the non-default states and makes default more likely, while an increase in T increases his payoff in all states. However, an increase in T must be offset by a more-than-proportional increase in F to satisfy the investors' individual rationality constraint (since, in the default states, investors receive less than F as the outcome of debt renegotiation). Thus, a rise in both T and F that satisfies the investors' individual rationality constraint helps the entrepreneur in the default states and hurts him in the non-default states. The payment T therefore allows the entrepreneur to shift resources from the "good" non-default states into the "bad" default states. The transfer is helpful because it allows the entrepreneur to limit inefficient liquidations in the bad states, but it comes at the cost of a reduction in the reinvestment at rate r in the good states. The optimal contract (T, F) will trade off the costs and benefits of cross-subsidization between states. These considerations suggest that contracts will tend to have low T and F values ("fast contracts") when the reinvestment opportunities ρ are expected to be high, and that they will have high T and F values ("slow contracts") when expected liquidation losses are very costly.

In the previous two papers, the allocation of the right to control the firm's assets after the realization of the first cash flow (that is, the liquidation/ continuation decision) is used as a device to induce the entrepreneur to make a payment to the investor. In Zender (1991), the allocation of the control rights is used to improve investment decisions. In this study, both the entrepreneur and the investor are risk neutral and output is verifiable. However, the realization of the second cash flow, x_2, requires at $t = 1$ (after the realization of a public signal s_1 on the future cash flow x_2) a second investment I_1, which affects the probability distribution of x_2. The party in control at that time (i.e., the entrepreneur or the investor) makes the investment I_1 by using first-period cash flow x_1, and he or she retains the residual $x_1 - I_1$. The level of investment I_1 is observable only by the agent who makes the investment, introducing moral hazard. Zender shows that the optimal security jointly determines the allocation of the cash-flow rights at $t = 2$ and of the control rights at $t = 1$, which is made contingent on the observation of the signal s_1.

The joint determination of the cash-flow and control rights in the security design problem allows the entrepreneur (and the investor) to improve the efficiency of the investment decision. In this way, the paper is reminiscent of that of Aghion and Bolton (1992), in which interim renegotiation and reallocation of control rights between the entrepreneur and the investor allow the two parties to make better payoff-relevant but non-contractible decisions. Zender (1991) shows that, depending on the properties of the conditional distribution $f(x_2 \mid s_1)$, it is possible to implement the first-best investment decision by writing a set of contracts that give the control rights, at $t = 1$, to the agent who is the residual claimant at $t = 2$. Thus, the optimal contract is a combination of debt and equity, where in the good states (high realization of the signal s_1) control rights rest with equity holders, and in the bad states (low realization of the signal s_1) control is allocated to the creditor, who now makes the investment decision. Note that the allocation of the control rights to the investor in the bad state may not be the only case in which the transfer of control is optimal. In other cases, the optimal contract may specify the transfer of control to the investor in certain good states. Kalay and Zender (1997) show that the state-contingent transfer of control may be achieved through the inclusion of warrants in the financing contract, improving incentives. Thus, the use of convertible securities (such as convertible debt or convertible preferred stock) complements bankruptcy as a mechanism for transferring control from the entrepreneur to outside investors.

Finally, Harris and Raviv (1995) consider the optimal security design problem in a setting similar to that of Hart and Moore (1989). This paper analyzes, in addition to the optimal design of the security, the optimal design of the negotiation game between the entrepreneur and investors. In particular, Harris and Raviv allow for a negotiation game at $t = 1$ in which both players simultaneously make a verifiable announcement of the state of nature; after that, payments and liquidation are determined as a function of these announced reports. The key result of the paper is that this *universal game* can achieve a more efficient outcome than the one proposed by Hart and Moore (1989). The reason is that making payments and liquidation decisions contingent on these reports indirectly allows for contracts to become state contingent and therefore further reduce inefficient liquidations.

4. Debt contracts and the provision of incentives

In the models discussed so far no consideration is given to the importance of giving the entrepreneur sufficient incentives to take the appropriate action $a \in A$. The problem of providing appropriate incentives to the entrepreneur is, however, a critical issue because debt contracts in which default risk is a distinct possibility distort the entrepreneur's incentives and may lead him either to exert too little effort (i.e., see the underinvestment problem of Myers, 1977), or to take too many risks (i.e., see the risk-shifting problem of Jensen and Meckling, 1976, and Galai and Masulis, 1976).

When the entrepreneur's choice of the action $a \varepsilon A$ is not contractible, while output is observable, investors are exposed to moral hazard, and the design of optimal incentive contracts becomes critical. For a risk neutral entrepreneur, the optimal incentive contract prescribes that the entrepreneur pay the investors a fixed flat payment (see Shavell, 1979, and Harris and Raviv, 1979), thus leading to risk-free debt. In many cases, and arguably the most common ones, limited liability makes these contracts infeasible. The effect of limited liability on the choice of optimal incentive contracts is examined in Innes (1990). In that paper, both the entrepreneur and investors are risk neutral, avoiding risk-sharing considerations, and the entrepreneur's action $a \varepsilon A$ increases expected output in the sense of the monotone likelihood ratio property (MLRP) of Milgrom (1981). Informally, this means that a high-output realization is more likely to be the result of a high level of the action a rather than a low one. In this case, the optimal incentive contract has a "live-or-die" feature, whereby the entrepreneur pays the investor a constant share of output when output is below a certain critical level and retains all the output otherwise. In this case, the entrepreneur captures all the benefits of effort in the better states, maximizing his incentives to exert effort. If the optimal incentive contract must also satisfy the condition of being monotonic in output (to eliminate the entrepreneur's incentive to manipulate the firm's profits, for example, by borrowing funds and artificially inflating output to reduce the payment to the invstor), the optimal contract is again a standard debt contract: The entrepreneur's effort is maximized by a contract that gives the entrepreneur maximal payoff in the high-output states and minimal payoff in the low-output states- that is, by a standard debt contract.

Entrepreneurial risk neutrality is critical in Innes (1990) to obtain that the optimal contract is a standard debt contract. In general, if the entrepreneur is risk averse, optimal contracts require some risk sharing between the (possibly risk-neutral) investor and the entrepreneur, making standard debt contracts suboptimal. Thus, the desire to provide appropriate incentives to the entrepreneur comes at a cost of inefficient risk sharing. This implies that the entrepreneur and the investor will find it optimal to renegotiate the initial contract once it is known to both parties that the entrepreneur has taken the action $a \varepsilon A$, and therefore incentive provision is no longer necessary. Contract renegotiation will also be beneficial because it allows the entrepreneur and investors to achieve optimal risk sharing by using relatively simple contracts (see Gale, 1991). The possibility of renegotiation, optimal ex-post, is, however, problematic ex-ante because it is anticipated by the entrepreneur and this undermines his incentives. Matthews (2001) examines the problem of the optimal ex-ante contract design when renegotiation is possible and finds that standard debt contracts are again (approximately) optimal in the class of monotonic contracts with limited liability.

Chiesa (1992) shows that if the interim signal $s \varepsilon S$ is observable to both the entrepreneur and the investor, but is not verifiable, the optimal contract is again a debt contract, in which the investor now holds a warrant on entrepreneur's equity and the entrepreneur has the option, if the warrant is exercised, to settle with a (delayed) cash payment to the investor. In this setting, the investor observes the realization of the interim signal s and decides whether or not to exercise the warrant. The entrepreneur, rather than diluting his equity, prefers to settle with a cash payment at the maturity of the debt, effectively increasing the payment to the investor. In this way, the investor's decision to exercise the warrant (contingent on the observation of the signal) and accept the cash settlement option results in a state-contingent payment to the investor that shifts payments from bad states into good states. This strategy reduces the debt-overhang problem, improves the entrepreneur's incentives, and alleviates the moral hazard problem.

In a similar vein, Povel and Raith (2004) consider a version of Hart and Moore's (1998) model in which now the level of investment *I* and the entrepreneurial action *a* may not be observable (and thus contractible) by the investor. The unobservable action *a* may be interpreted either as entrepreneurial effort or as the choice of a risky project (generating risk shifting). Povel and Raith show that the optimal contract is again a debt contract, in which the probability of liquidating the project is chosen optimally to induce the entrepreneur either to invest in the project, or to exert effort, or to choose a project with a desirable risk profile.

5. Debt contracts under asymmetric information

The common feature of the models discussed in the previous sections is that the entrepreneur and investors have access, at the time they negotiate the financing terms, to the same information. The availability to the entrepreneur of pre-contractual payoff-relevant information exposes investors to adverse selection and impairs the entrepreneur's ability to raise capital.

Assume now that at the outset of the game the entrepreneur privately observes the realization of the variable $\theta \, \varepsilon \, \Theta$. The parameter θ induces a conditional probability distribution function (PDF) over output $P(x \mid \theta)$ and identifies an entrepreneur's "type." Investors respond to the potential "lemon problem" (see Akerlof, 1970) by financing entrepreneurs at terms that reflect the average quality of the pool of entrepreneurs seeking financing. In this way, the presence of asymmetric information causes a wealth transfer from better-quality entrepreneurs to lower-quality ones, increasing the financing cost of better-than-average entrepreneurs. Two influential papers, Myers and Majluf (1984) and Myers (1984), suggest that, under these circumstances entrepreneurs with better information can reduce the "lemon discount" they face by adopting a financing strategy that follows a well-defined "pecking order": They should satisfy their financing needs first by using securities that are less sensitive to information asymmetries, such as safer debt, and then by progressively using securities that have increasing information sensitivity, such as riskier debt and finally equity.

Whether the presence of asymmetric information necessarily leads to a preference for securities with low information sensitivity over information-sensitive ones (and, thus, to a preference for debt over equity) has been investigated by several papers in the subsequent literature.

The ability of the entrepreneur to commit his own wealth to the project may be useful in discouraging lower-quality entrepreneurs from seeking financing, improving the average quality of the pool of entrepreneurs facing investors. Narayanan (1988) assumes that the parameter $\theta \, \varepsilon \, \Theta$ orders the PDF of output, $P(x \mid \theta)$, by "first-order stochastic dominance" (FOSD) (that is, $P(x \mid \theta_1) < P(x \mid \theta_0)$ for any $\theta_0 < \theta_1$); that entrepreneurs may have projects with negative net present value (NPV); and that the choice of financing is exogenously restricted to either risky debt or equity. By using risky debt rather than equity, entrepreneurs with better information reduce the wealth transfer to the lower-quality entrepreneurs (that is, those with negative NPV projects) and discourage them from investing in the project, leading them to drop out of the market. Thus, the use of debt improves the average quality of the pool of entrepreneurs who seek financing, and reduces adverse selection costs.

Noe (1988) shows that if entrepreneurs have no initial wealth and their pre-contractual private information, θ, does not resolve all the residual uncertainty (that is, it does not fully reveal the realization of the final output x), the preference for debt over equity is not a generic implication of asymmetric information, even when the private information θ orders the PDF of output $P(x \mid \theta)$ by FOSD. Specifically, the paper offers an example in which the entrepreneur may be one of three possible types, $\Theta = \{\theta_1; \theta_2; \theta_3\}$, where θ_i is a "better" type than θ_j if and only if $i > j$. Entrepreneurs of the better type, θ_3, pool with the lower type, θ_1, and both issue risky debt, while entrepreneurs of intermediate value, θ_2, separate and issue (fairly priced) equity. This happens because the lower type prefers to pool with the better type and issue overvalued debt rather than mimicking the middle type and issuing overvalued equity. The better type prefers to pool with the lower type and issue undervalued debt rather than mimicking the middle type and issuing undervalued equity. The intermediate type prefers to issue equity and separate, rather than issuing undervalued debt.

The specific properties that the probability distribution of the project's output, $P(x|\theta)$, must satisfy to ensure that a firm's insiders prefer debt over equity are identified by Nachman and Noe (1994). This study assumes that entrepreneurs have access only to positive NPV projects and imposes minimal restrictions on the set of admissible securities, $y(x)$, by assuming that entrepreneurs can issue any security that satisfies limited liability, $0 \leq y(x) \leq x$, and monotonicity, $0 \leq y'(x) \leq 1$. The paper shows that the predictions of the pecking order theory hold if and only if the parameter θ orders the PDF of output, $P(x \mid \theta)$, by *conditional* stochastic dominance, that is, if the conditional probability

$$P(y \mid x, \theta) \equiv \frac{P(x + y \mid \theta) - P(x \mid \theta)}{1 - P(x \mid \theta)} \tag{1.8}$$

is ordered by FOSD by θ for all x. Conditional stochastic dominance, in turn, implies that

$$R(\theta_1, \theta_2) \equiv \frac{1 - P(x \mid \theta_2)}{1 - P(x \mid \theta_1)}, \quad \text{for any } \theta_1 < \theta_2 \tag{1.9}$$

is non-decreasing in x (note that FOSD implies only that $R(\theta_1, \theta_2) \geq 1$). The ratio (1.9) has the interesting interpretation of representing the marginal cost of increasing the payout for type θ_2 relative to type θ_1. For debt to be optimal, it is necessary (and sufficient) that the relative incremental cost of increasing a payout for a better type of entrepreneur is non-decreasing in the output level x. In this case, better types are better off increasing the payout to investors in the low-output states and reducing the payout to investors in the high-payout states. These considerations, together with the requirement that the security be monotonic in output, lead to the optimality of debt contracts.

The importance of the assumption that the entrepreneur has access only to positive NPV projects is highlighted by Ravid and Spiegel (1997). In their model, entrepreneurs have access to a limited number of positive NPV projects, but they can freely create projects with any arbitrary output distributions $P(x)$ as long as these projects have a negative NPV. In this case, only contracts that are linear in output x, namely equity contracts, are immune to manipulation. This happens because linear contracts are the only ones that align the entrepreneur's interest with the investors'.

In the real world, debt contracts often come in simple form, that is, payments from the entrepreneur to the investor are not made contingent on information that is publicly available. For example, in standard debt contracts the entrepreneur makes non-contingent payments, whereas in income bonds interest payments are made contingent on certain accounting measures of profits. If the entrepreneur is risk averse, such non-contingent contracts are in general suboptimal because they forego some risk-sharing opportunities that are offered by the linking of payments to (noisy) signals of the true state of the world (see, in the context of moral hazard, Holmstrom, 1979, and Shavell, 1979). This raises the question why non-contingent debt contracts are so pervasive. In an adverse selection context, Allen and Gale (1992) show that if the signals to be included in the debt contract (for example, accounting measures) can be manipulated by the entrepreneur, the proposal by the entrepreneur to include contingencies in the financing contract may be interpreted by the investor as a bad signal on the entrepreneur's private information. This happens when entrepreneurs of the "good" type have lower incentives to manipulate the signal than do those of the "bad" type and, therefore, can separate by offering non-contingent contracts. In this setting, in equilibrium entrepreneurs of different types pool and offer non-contingent contracts, which is the only contract in which entrepreneurs have no incentive to manipulate the signal.

An important assumption of Nachman and Noe (1994) is that outside investors are endowed with an exogenous amount of information and that their information acquisition plays no role in the entrepreneur's security design problem. Boot and Thakor (1993) examine the case in which some investors can, by paying a certain cost, learn the realization of θ, reducing the extent of the asymmetric information. Informed investors, however, have limited wealth and can purchase only a small number of shares, determined endogenously. Securities are sold by the entrepreneur in an anonymous market, in which prices are set competitively by risk-neutral market makers. The ability of equilibrium security prices to reflect the information produced by the informed investors is reduced by the presence of noisy (uninformed) investors. Entrepreneurs are one of two possible types, "good" and "bad," sell their firm in its entirety, and are willing to accept any price determined in equilibrium by the market makers (that is, they have no reservation price for their firm). Boot and Thakor show that the entrepreneur's revenue-maximizing strategy is to split the claims on the firm's output into one information-sensitive security, such as equity, and a second less information-sensitive security, such as debt. The intuition is that by creating an information-sensitive security, entrepreneurs reward information acquisition and induce more investors to become informed. Entrepreneurs with more valuable firms benefit because greater information production moves the (expected) equilibrium prices closer to the greater intrinsic value of the securities they sell.

Note that in Boot and Thakor (1993) the value to investors of becoming informed derives from their ability to trade against liquidity traders. Thus, the increase in information production from the creation of these two securities relies critically on how the liquidity traders split their trading between the two securities. For example, if most of the liquidity traders choose to trade in the security that is less information sensitive, then information production will actually decrease following the creation of the two securities. Goldman (2005) shows explicitly that the aggregate level of information production can either increase or decrease following a spin-off of an all-equity firm (i.e., a firm that switches from having one information-sensitive security to having two). His analysis allows for any possible split of the initial liquidity traders between the two newly created securities.

One implication of Boot and Thakor's model is that entrepreneurs should always prefer to use an information-sensitive security, such as equity, to an information-insensitive one, such as debt; this reaches the opposite conclusion of the pecking order theory. Fulghieri and Lukin (2001) reconcile the findings of Boot and Thakor with those of Myers and Majluf (1984), as follows. In a setting similar to that of Boot and Thakor, they assume that entrepreneurs seek financing only to the extent necessary to fund the investment, *I*, thus requiring entrepreneurs to maintain a residual interest in their firms. Entrepreneurs have either "good' or "bad" projects, where bad projects are those that have negative NPV. Securities are sold by the entrepreneur in an anonymous market, in which prices are set competitively by risk-neutral market makers who observe aggregate order flow. This differs from Boot and Thakor (1993) in that now a low realization of uninformed investors' demand can decrease aggregate order flow to the point that the equilibrium price set by the market makers is too low to enable the entrepreneur to raise the desired amount *I*, leading to a failure of the security issuance.

Fulghieri and Lukin (2001) show that the promotion of informed trading by the issuance of equity rather than risky debt is beneficial to good-quality entrepreneurs only if the equilibrium amount of informed trading is sufficiently large and, thus, the cost of acquiring information is low. This can be seen as follows. With no informed trading, both good and bad projects are successfully financed for any realization of the order flow (because, on average, they have a positive NPV), and entrepreneurs issue a security with low information sensitivity for precisely the same reasons as the one discussed in Myers and Majluf (1984). With informed trading, order flow is informative on project quality and, thus, it affects the price of the securities issued by the entrepreneur. When information production costs are high (and, thus, the equilibrium amount of informed trading is low), the use of an information-sensitive security such as equity promotes informed trading only moderately. When, instead, information production costs are low (and therefore the equilibrium amount of informed trading is high), the promotion of informed trading by the issuance of an information-sensitive security increases the probability that securities are issued and that the project is implemented. Thus, when the information production costs are relatively high, the entrepreneur follows optimally the prescriptions of the pecking order theory and prefers debt to equity; when, instead, the information production costs are relatively low, the entrepreneur prefers to use equity rather than debt, counter to the pecking order theory. Moreover, Fulghieri and Lukin show that the benefits of promoting information acquisition through equity financing are greater when it is needed most, that is, in cases in which the entrepreneur faces greater information asymmetry. Finally, the paper solves the optimal security design problem, showing that when information production costs are large, the entrepreneur will issue risky debt, and when information production costs are low, the entrepreneur will issue a security with a convex payoff, such as equity plus warrants.

A key assumption of the previous papers is that entrepreneurs optimally design the security they offer for sale in the interim (in the sense of Holmstrom and Myerson, 1983), that is, *after* they have observed their private information. However, it is interesting to examine the entrepreneurs' security design problem *before* they learn their private information, that is, before the realization of $\theta \, \varepsilon \, \Theta$. The difference between the ex-ante and the interim security design problems is critical since, ex-ante, entrepreneurs face uncertainty on the private information that they will receive, that is, on their own type. Entrepreneurs solve the ex-ante security design problem by anticipating that because of the private information they will receive, they will not face a perfectly elastic demand function for their securities, even in competitive capital markets. Rather, as discussed in Leland and Pyle (1977), rational investors anticipate that entrepreneurs will be willing to sell a greater amount of securities (relative to what they maintain in their portfolio) when these have lower value according to their private information. Thus, the presence of private information leads quite naturally to downward-sloping demand functions for securities and, therefore, to illiquid securities markets.

The ex-ante optimal security design problem is tackled by DeMarzo and Duffie (1999). Risk-neutral entrepreneurs choose the design of the security put up for sale, that is, its payoff *y*, before they observe their private information, $\theta \varepsilon \Theta$. The security payoff y is restricted to be a monotonic increasing function of the firm's output x and, possibly, of an additional public signal, $s \varepsilon S$; that is, $y(x, s) \varepsilon [0, x]$. Entrepreneurs design the security payoff $y(x,s)$ anticipating that investors will be willing to pay a price, V, which depends (endogenously) on the choice of the payoff structure $y(x,s)$ of the security put up for sale (that is, on the specific security design), and on the fraction q of the security that is held by the entrepreneur in his portfolio. Thus, $V = V(y(x,s), q)$. An entrepreneur anticipates that he will in general obtain a better price if he retains a greater fraction q, but at the expense of suffering a cost per unit of retained output. The sale of the security occurs only after the entrepreneur observes the private information. Demarzo and Duffie show that if the private information θ has a "uniform worse case" (a property that is shown to be weaker than MLRP), then the solution to the ex-ante optimal security design problem is again a standard debt contract. This happens because the severity of the illiquidity faced in the interim by the entrepreneur depends on the sensitivity of the security offered for sale to the entrepreneur's private information. Thus, by issuing a security with low information sensitivity, the entrepreneur reduces the future illiquidity, which enables him to reduce costly retention.

In a subsequent paper, DeMarzo (2005) shows that if the entrepreneur designs the security payoff *after* he learns the private information θ, the optimal contract is still a standard debt contract, in which now the face value is a decreasing function of θ. Thus, a larger debt issue is interpreted by investors as negative signal about the valuation of the firm. More generally, DeMarzo considers an entrepreneur endowed with multiple assets and examines the problem of whether or not he should pool his assets in a single firm ("pooling"), and the subsequent priority structure of the securities issued ("tranching"). Pooling assets in the same firms has an information-destruction effect. This is beneficial to the entrepreneur if he is uninformed at the time of the securities' issuance, since it reduces the underpricing due to the "winner's curse" problem (see Rock, 1986). Pooling is detrimental if the entrepreneur is informed when the securities are issued, since it reduces his flexibility to selectively sell each security depending on the private information he has obtained. Furthermore, DeMarzo shows that pooling and tranching are beneficial when the residual risks of assets are not too highly correlated, since this strategy allows the entrepreneur to create a low-risk, highly liquid security which he would be able to sell for a better value.

Biais and Mariotti (2005) extend DeMarzo and Duffie's analysis and assume that the entrepreneur does not face fully competitive investors (as in DeMarzo and Duffie, 1999), but rather liquidity suppliers with a certain market power. The entrepreneur again designs the security before becoming informed, that is, before observing θ. The optimal security design problem results again in a standard debt contract, that is, a security with low information sensitivity, in which the choice of the face value of the debt allows the entrepreneur to reduce the rents extracted by the liquidity provider.

In DeMarzo and Duffie (1999), security design is made by the entrepreneur before becoming informed. Inderst and Mueller (2006a), conversely, examine the security design problem faced by a risk-neutral, uninformed investor in the case in which the investor (rather than the entrepreneur) becomes informed before deciding whether or not to provide financing to the entrepreneur. Specifically, the investor privately observes the realization of the signal θ and, given the contract design chosen in advance, must then decide whether or not to finance the risk-neutral entrepreneur. The signal θ is informative on output level; that is, $F(x, \theta)$ again satisfies MLRP. The entrepreneur has no wealth, so the investor must provide full financing. Under the first-best, the project is undertaken if and only if the observed signal θ is greater than a certain critical level θ_c, which depends on the investment I and on the entrepreneur's reservation utility. The security design problem is made interesting by the fact that the investor's decision to finance the entrepreneur is subject to two kinds of biases (with respect to the first-best decision rule). The first bias is that the investor does not internalize the entrepreneur's reservation utility, leading to more frequent acceptances of the project than under the first-best case (i.e., the investor is too aggressive). The second bias is that the investor must surrender surplus to the entrepreneur, leading to less frequent acceptances of the project than under the first-best (i.e., the investor is too conservative). Inderst and Mueller show that when the second effect prevails, that is, when the investor is too conservative, the solution to the optimal security design problem is a standard debt contract: $y(x) = min \{x; F\}$, where $F > I$. The intuition is as follows: By giving the investor the entire payoff in the low states, the contract brings the critical threshold, θ_c, closer to the first-best. Conversely, when the investor is too aggressive, the optimal contract is levered equity: $y(x) = max \{x- F; 0\}$, with $F > 0$. This implies that the standard debt contract emerges again as the outcome of an optimal security design problem in cases in which investors are by their nature too conservative. In addition, Inderst and Mueller (2006b) show that adding collateral may also reduce the inefficient lender's acceptance decision by improving the investor's payoff for low but still positive NPV projects that would otherwise be rejected.

6. The structure of debt contracts

Debt contracts rarely come in the "plain vanilla" form discussed in the previous sections. More realistically, debt contracts include specific provisions designed to further mitigate the effect of asymmetric information and, thus, to facilitate the effective financing of the entrepreneur's project. In this section, we discuss the role of specific characteristics of debt contracts such as seniority, maturity structure, collateral, and covenants. Note that while these contractual features are very often bundled together in the same debt contract, for expositional purposes we discuss them individually in separate subsections.

a. Seniority

Debt seniority is defined as the priority that a claim holder has over other claim holders when the firm's cash flow is insufficient to pay all obligations. Seniority can matter in the case of liquidation or bankruptcy, but it is also relevant for the case in which debt restructuring takes place, as it defines the payoffs in the state of no agreement. Note that debt maturity implies some form of seniority. This is because short-tem debt, by virtue of the fact that it is paid earlier, is essentially senior to long-term debt. In this section, we will discuss seniority in the strict sense, that is, the priority structure of claims maturing at any given date. We will defer to the next section on maturity the discussion of the more general issue of combining seniority and maturity structure.

In the basic *CSV* setting discussed in Section 2, the optimality of the debt contract is established under the assumption that either the entrepreneur receives financing from a single investor, or that he borrows from multiple investors who observe the outcome of the state verification simultaneously. If the entrepreneur needs to raise capital from more than one investor and the outcome of the state verification is now privately observed by the investor that performed the verification, the standard debt contract is no longer optimal. Winton (1995) shows that in this case symmetric debt contracts are suboptimal because (i) they entail duplication of verification cost, and (ii) they involve suboptimal risk sharing. Assuming investors are risk neutral, the optimal contracts are debt-like contracts with absolute priority among investors holding claims with different seniority. The entrepreneur issues separate "tranches" of debt, where investor i has debt with a face value of F_i and where seniority is defined as the region over which an investor chooses to monitor. For two investors i and j, if i monitors for all reported output $x < F_i$ and j monitors for all reported output $x < F_{j,}$ then i is said to be senior to j if $F_j > F_i$. Furthermore, Winton shows that if all investors are identical, that is, if they have the same risk preferences and endowments, debt-like contracts of varying seniority still dominate symmetric contracts with identical seniority. While seniority reduces the value of junior debt (making it more risky), in most cases the benefit of reducing verification costs outweighs the reduction in risk sharing among investors.

Seniority of claims also matters because it affects investors' incentives. Park (2000) considers a situation in which the entrepreneur may engage in asset substitution by taking on a risky (rather than a riskless) project. In this setting, monitoring by investors can deter the entrepreneur from this opportunistic behavior. Park endogenizes the incentive to monitor and argues that in order to minimize the contracting costs the entrepreneur must maximize the investors' incentive to monitor. This can be achieved with an optimal debt structure in which the investor with the smallest monitoring cost receives senior debt, while the investor(s) with the highest monitoring cost receive(s) junior debt. The reason is as follows. The incentives to monitor are greater when the benefits from the monitoring activity are greater. Because senior debt holders do not get paid in full upon liquidation, they will have an incentive to monitor the entrepreneur and thus prevent asset substitution. Hence, investors with lower monitoring costs should hold a claim senior to all other investors in liquidation. Junior debt holders, however, will not receive much in liquidation, and therefore have little incentive to monitor. Thus, junior claims should be held by investors with the highest cost of monitoring.

In addition to affecting investors' incentives, seniority structure can also influence the entrepreneur's incentives to fight off investors in the case of financial distress, for example, through costly litigation. Litigation under financial distress is inefficient because it has the sole effect of redistributing wealth across agents, and therefore represents a pure deadweight cost. Welch (1997) considers a case in which the entrepreneur has (exogenously) issued debt to two investor types: a large investor (say, a bank), and a group of small investors. Welch's model analyzes the entrepreneur's ex-ante decision regarding which of the two types of investors should hold a senior claim. Welch shows that, all else held equal, if the firm wants to minimize the costs of wasteful lobbying during the bankruptcy process then it should award seniority to the investor with the lowest lobbying cost (i.e., the bank). With no lobbying, the court (by assumption) is more likely to rule in favor of the absolute priority rule. Hence, the junior debt holder will have the weakest incentive to engage in lobbying activities. Thus, to minimize lobbying costs the entrepreneur should give the junior claims to the investor with the highest lobbying cost and the senior claim to the bank that has the lowest lobbying cost.

b. Maturity structure

Closely related to the issue of seniority is the choice of debt maturity structure. Debt seniority and maturity are closely related features of debt contracts because debt with a short maturity is in a way senior to debt with a longer maturity. Stewart Myers was the first to recognize the importance of the maturity date of debt relative to the timing of the entrepreneur's investment opportunities. In Myers (1977), the entrepreneur is endowed with the option to invest (say, at $t = 1$ in our setting) in a new positive NPV project. The paper shows that if the entrepreneur has outstanding debt (issued, for example, at the beginning date $t = 0$) and maturing at a later date (say, at $t = 2$), he may prefer to forego the new project rather than committing additional capital. This happens whenever the NPV of the new project is smaller than the total wealth that is transferred to the existing debt holders as a result of the acceptance of the new project. Thus, issuing debt at $t = 0$ reduces the entrepreneur's incentives to undertake profitable projects in the future, generating an underinvestment (or, debt-overhang) problem.

The above underinvestment problem is caused by the presence of existing debt that matures after the expiration of the new investment opportunity. This implies that, by careful choice of the debt maturity structure, the entrepreneur may alleviate the adverse incentive effect of debt. This is shown in the study by Barnea, Haugen and Senbet (1980), who argue that the combined issuance of short-term debt, maturing before the expiration of the new investment opportunity, along with long-term debt with a call provision, restores investment incentives and eliminates the underinvestment problem.

The fact that the presence of long-term debt leads to underinvestment is not always detrimental, but may in fact be desirable in situations in which the entrepreneur has an incentive to overinvest. Berkovitch and Kim (1990) consider the problem faced by the entrepreneur at $t = 1$, when the firm already has debt outstanding (issued, say, at $t = 0$ to acquire assets) and needs to finance an additional project whose returns are his private information. The choice of seniority between the existing long-term debt and the new short-term debt issued at $t = 1$ affects the entrepreneur's incentives to over- and underinvest in the new project. Their paper shows that if the likelihood of overinvestment is high (i.e., when the new project is more likely to have a negative NPV), then new debt issued at $t = 1$ should be junior to the existing long-term debt. This is because junior debt limits the additional amount that the entrepreneur can borrow and hence discourages investment. Conversely, when the new project is more likely to have a positive NPV, it is optimal to reduce the possibility of underinvestment by allowing the entrepreneur to issue new debt senior to existing long-term debt. Finally, the authors show that when the future investment is known to all, then the optimal new debt is one that is fully collateralized by the new project with no recourse to existing assets. Thus, with no information asymmetry, the best outcome is achieved by separating the projects from existing assets-in-place.

Houston and Venkataraman (1994) also focus on the costs and benefits of the underinvestment problem caused by debt and on the beneficial impact of debt on the forcing of liquidation in cases in which the entrepreneur has the incentive to invest in projects with negative NPV. They show that the entrepreneur can commit at $t = 0$ to an optimal liquidation policy at $t = 1$ with an appropriate mix of short- and long-term debt. In particular, short-term debt is higher the higher the expected liquidation value.

In a similar vein, in Hart and Moore (1995) the entrepreneur is assumed to have private benefits of control, which implies that he always wishes to invest in new projects (provided that he has access to capital) even when these projects are inefficient. In Hart and Moore's setting, overinvestment may occur at the interim, $t = 1$, when the entrepreneur can invest in a new project that requires a new investment in the amount of I_1 and generates at $t = 2$ an (additional) cash flow equal to Δx_2. The entrepreneur's ability to invest in new projects at $t = 1$ is constrained in two ways. First, the presence of short-term debt, with face value F_1 and maturing at $t = 1$, forces the entrepreneur to disburse cash flows from assets-in-place, x_1, to investors, thereby limiting his ability to invest in the new project. The use of short-term debt, however, may come at the cost of potential inefficient liquidation at $t = 1$ of assets-in-place to repay maturing short-term debt. Second, the presence of *senior* long-term debt, with face value F_2 and maturing at $t = 2$, limits the entrepreneur's ability to raise additional capital at $t = 1$ by borrowing against future earnings. Hart and Moore (1995) argue that the long-term debt (issued at $t = 0$) should be senior to any short-term debt that the entrepreneur would issue at $t = 1$. Specifically, if long-term debt is senior, the entrepreneur can raise enough capital and invest in the new project at $t = 1$ if and only if $x_1 + x_2 + \Delta x_2 - F_2 \geq I_1 + F_1$ (assuming risk neutrality and no discounting). If, instead, long-term debt is junior, the entrepreneur is able to raise money and invest in the new project only if $x_1 + x_2 + \Delta x_2 \geq I_1 + F_1$. Thus, if existing long-term debt is junior, the entrepreneur can raise more capital, exacerbating the overinvestment problem. Seniority of long-term debt tightens the entrepreneur's budget constraint at t = 1 and limits his ability to raise capital and invest in negative NPV projects. The benefit of the seniority of long-term debt, however, comes at the cost of foregoing some positive NPV projects at t = 1, when the (expected) value of future cash flow, x_2, is low and the entrepreneur cannot raise sufficient funds to invest in profitable new projects.

The optimal choice of debt maturity structure must be made in harmony with the time profile of the payoff of firm assets. The issue of the appropriate matching between the maturity structure of assets and liabilities is examined by Hart and Moore (1994), which is a dynamic extension of Hart and Moore (1989) and (1998) discussed in Section 3. In Hart and Moore (1994), project cash flows, x_t, and debt payments accrue continuously over a finite horizon, $t \varepsilon [0, T]$. The debt maturity structure is modeled as the rate at which debt payments are made. Debt contracts with slower debt payments imply longer maturity. The main problem faced by the entrepreneur is that he cannot commit not to withdraw his human capital from the project. This means that under any debt contract and at any given point in time, the investor cannot receive more than $\max(0.5x_t, L_t)$, where the first term is the present value of what the investor can get in renegotiation with the entrepreneur following a default (under the assumption that entrepreneur and investor split the continuation payoff), and the second term is what the investor can get if he chooses to liquidate. Liquidation, however, is inefficient due to the loss of the entrepreneur's human capital.

Under these circumstances, the authors show that the amount of long-term debt that the entrepreneur can issue is constrained by the investor's understanding that debt value will be renegotiated down to $\max(0.5x_t, L_t)$. In turn, short-term debt maturing at τ cannot be greater than what can be repaid with existing cash flows and cash flows retained from excess profits saved from $t < \tau$. Although the model yields a multiplicity of debt maturities for the contracts that achieve first-best, the authors show that the intertemporal profile of project returns affects the maturity structure of the slowest and fastest possible debt contracts. For example, when more of the project returns arrive early (or, are front-loaded) the debt payments become faster (i.e., have lower maturity). This is because the investor has less to bargain over in the future, and hence he requires more payments up front. Furthermore, if the entrepreneur has a greater discount rate than the investor (which can happen if the entrepreneur has profitable investment opportunities), the optimal contract is unique and is the slowest possible debt contract (i.e., has longer maturity).

Using a framework similar to that of Hart and Moore, Berglof and Von Thadden (1994) shows the importance of maturity when the entrepreneur is again able to strategically default and threaten to withdraw his human capital. In this model, the entrepreneur has assets in place which generate cash flows, x_t, over two periods, t = 1,2. While assets, with a liquidation value L_t, can be pledged to investors, cash flows cannot. The problem arises when asset value L_t is not large enough to induce investors to provide sufficient capital for investment. In this case, the only way to raise the necessary capital is to write a contract that induces the entrepreneur to give some of the non-contractible cash flow at the first date, x_1, to the investor. The entrepreneur has an incentive to do so because the investor can liquidate the project if not paid at the interim date, t = 1. This would result in a loss to the entrepreneur of the t = 2 cash flow, x_2. The main tradeoff is as follows. A higher debt payment at t = 1 (that is, a short maturity) results in more inefficient liquidation, but too small of a payment at t = 1 will not allow investors to recoup their initial expenditure, hindering investment. The ability to raise capital is further complicated by the fact that even when the t = 1 cash flows are high, the entrepreneur may still threaten to withdraw his human capital. Debt maturity then plays an additional role in the renegotiation game between the entrepreneur and the investor. Berglof and Von Thadden show that in order to minimize the amount of inefficient liquidation, the optimal contract needs to minimize the ex-post surplus that the entrepreneur is able to extract from the investor via strategic default at $t = 1$ when cash flows are high. This can be achieved by maximizing the investors' bargaining power or, rather, by minimizing their loss from liquidation. Because liquidation is harmful to long-term investors, the optimal contract separates investors into senior short-term lenders, who negotiate with the borrower at $t = 1$, and junior long-term lenders, who do not force liquidation. This choice of debt structure strengthens the short-term investor's position and, thus, minimizes the entrepreneur's incentive to strategically default on the loan in the hopes of renegotiating and getting better terms.

More recently, DeMarzo and Fishman (2006) have offered a theory of optimal long-term debt and outside equity in combination with a credit facility that allows the entrepreneur to smooth out temporary shocks to cash flow. They reconsider the Hart and Moore (1994) model in which a risk-neutral entrepreneur is endowed with a project that requires an investment I and generates a stochastic cash flow x_t and a liquidation payoff of L_t for $t \varepsilon [0, T]$. Cash flows, x_t, are identically and independently distributed (so there is no "learning") and can be diverted by the entrepreneur at a cost (making concealing cash flows inefficient). The paper solves for the optimal security design problem, showing that the optimal contract can be implemented by means of simple securities, whereby the investor holds a combination of long-term debt and equity and then provides the entrepreneur with a credit line. The entrepreneur, who holds the residual equity, must make a periodic payment on the long-term debt, and this payment is made either out of the periodic cash flow, x_t, or by drawing on the credit line. If the entrepreneur cannot meet the periodic payment on the long-term debt, the project may be liquidated (with a certain probability). In equilibrium, the entrepreneur uses all excess cash to pay down the credit line and then makes a dividend payment to equity rather than concealing cash flows. Thus, he finances consumption from the dividends received on his equity position.

DeMarzo and Sannikov (2006) reformulate the DeMarzo and Fishman (2006) model within a continuous-time framework. Their paper shows that in addition to debt, equity, and a credit line, the firm will also optimally hold cash as a requirement for obtaining the credit line. This cash holding allows the entrepreneur to obtain a greater credit line and provides an infusion of cash (the return on the cash holdings), which may be valuable when the risk of loss is high. Furthermore, termination of the project is deterministic (no randomization is necessary, as in DeMarzo and Fishman, 2006). Sannikov (2006) extends the model further by assuming that at the outset of the project, the entrepreneur has private information on the mean of the future cash flow distribution. Sannikov shows that in this case the optimal contract is a credit line with a growing credit limit, with the requirement that the entrepreneur contribute at the outset a certain minimum amount of initial capital. The minimum equity participation by the entrepreneur is needed to discourage entrepreneurs with unworthy projects from mimicking the behavior of entrepreneurs with positive NPV projects and having access to the credit line offered by investors. Furthermore, the increasing credit limit feature is due to adverse selection, which limits the amount that investors can give to the entrepreneur; over time, investors are willing to increase the credit limit as the entrepreneur signals to investors his type by making the accrued contractual payments on existing debt.

Debt maturity structure also affects the entrepreneur's exposure to adverse changes in credit quality and, therefore, to liquidity risk. This problem is first examined in Flannery (1986), which shows how the choice of debt maturity can be used by good entrepreneurs (i.e., those with good information at $t = 0$ about future cash flow), to signal their type and thus separate from bad entrepreneurs. In Flannery's model, entrepreneurs need to raise debt to finance a two-period project. The assumed cash flow distribution implies that short-term debt, maturing at $t = 1$, is riskless, but long-term debt, maturing at $t = 2$, is not. Good entrepreneurs have a higher probability of high cash flow, and this information is updated in the first period. Thus, short-term debt is preferred by good entrepreneurs because it allows for more information-sensitive securities, while bad entrepreneurs prefer long-term debt. However, since the choice of debt reveals information, bad entrepreneurs mimic good ones and hence all entrepreneurs pool at $t = 0$ and issue short-term debt (which is priced based on the average entrepreneur type). Flannery further shows that, if refinancing is costly (for example, if it requires a fixed transaction cost), then good entrepreneurs can separate themselves by issuing short-term debt, incurring the fixed cost of refinancing at $t = 1$ but also obtaining a lower refinancing rate due to the separation from bad types, which now issue long-term debt.

In Flannery (1986) entrepreneurs issuing short-term debt do not face the risk of liquidation, that is, the risk of not being able to refinance their debt at $t = 1$. The effect of liquidation risk on debt maturity and seniority is examined in Diamond (1991) and (1993). In these papers, the entrepreneur is again endowed with a technology lasting for two periods, but output is generated only in the second period, $t = 2$. The technology can either be "good" ($\theta = G$) or "bad" ($\theta = B$), and it is private information to the entrepreneur at $t = 0$. Good technologies are viable, while bad technologies have a negative NPV (in terms of cash flows). This implies that type B entrepreneurs must always pool with type G ones. The $t = 0$ probability that $\theta = G$ represents the entrepreneur's initial credit rating. The tension in the model comes from the fact that the entrepreneur has private benefits of control, which implies that he never wants to voluntarily liquidate the project at $t = 1$. Investors, who do not know the entrepreneur's type, receive at $t = 1$ a signal on entrepreneur type, which can either be good or bad. A bad signal induces the investor to reduce the probability that the entrepreneur is of good quality, and thus represents a "downgrade" of credit rating; similarly, a good signal represents an "upgrade." After observing this signal, lenders have the option to liquidate the firm unless the borrower is able to raise additional debt and pay off the initial short-term debt. The basic inefficiency is that lenders want to liquidate the firm at $t = 1$ too often because they do not internalize the borrower's private benefits of control.

When capital is raised at $t = 0$, the entrepreneur's project type is unknown, and hence debt is priced based on the average quality. The optimal financing mix is determined by type G entrepreneurs, since type B entrepreneurs always mimic type G ones. For type G entrepreneurs, the benefit of short-term debt, maturing at $t = 1$ when new information becomes available, is that it allows them to refinance debt at a better rate (with some probability) if they receive an upgrade. However, this comes at the risk of receiving a downgrade, forcing them to refinance at a worse rate or possibly to be liquidated. The benefit of long-term debt is that it allows the entrepreneur to lock in the interest rate at the current credit rating. The implications of the model are that issuers with either a very high or a very low initial credit rating will prefer to issue short-term debt. This is because borrowers with very low credit ratings will not be able to raise long-term debt (the promised face value is too high), while borrowers with very high credit ratings are less likely to receive a credit downgrade and therefore will want to capitalize on the arrival of new information and, thus, the possibility of a credit upgrade. When the average issuer quality is not too extreme, the optimal debt structure is to issue either long-term debt or a mix of long- and short-term debt. The optimal mix of debt maturity attempts to minimize the likelihood of early liquidation and loss of private benefits, while maximizing the sensitivity of debt to the arrival of new information (via increasing short-term debt, which may be refinanced at the intermediate date).

The role of seniority is further discussed in Diamond (1993), which uses a setting similar to that of Diamond (1991). Here, the choice of seniority between long-term debt issued at $t = 0$ and short-term debt issued at $t = 1$ (after the new information becomes available) is modeled explicitly. Diamond shows that seniority can be used to increase efficiency by maximizing the sensitivity of contracts to the release of interim information, while keeping the probability of liquidation at a fixed level. Debt seniority is modeled as the amount of $t = 2$ cash flow, x_2, that investors who provide long-term debt at $t = 0$ allow the entrepreneur to pledge at $t = 1$ to new investors, who provide new short-term debt. If at $t = 0$ the entrepreneur has issued long-term debt maturing at $t = 2$ with face value F_2, and if $F_{1,2}$ is the maximum face value of new short-term debt that the entrepreneur is allowed to issue at $t = 1$, then $F_{1,2}>x_2-F_2$ means that long-term debt is junior to the new short-term debt, and $F_{1,2}<x_2-F_2$ means that long-term debt is senior to the new short-term debt. The paper shows that the entrepreneur should be allowed to issue at $t = 1$ as much senior short-term debt as possible, that is, to set $F_{1,2}=x_2$. The intuition can be seen as follows. First, the liquidation decision at $t = 1$ is constant for any given ratio between $F_{1,2}$ and the amount of short-term debt maturing at $t = 1$, F_1. This happens because if F_1 and $F_{1,2}$ both increase by, say, a dollar, then the entrepreneur can raise an additional dollar at $t = 1$ by issuing an additional dollar of face value of new debt maturing at $t = 2$, thus not affecting the liquidation probability at $t = 1$. Second, since type B entrepreneurs offer the same contract as the type G ones, a type G entrepreneur will choose the contract that, for a given level of liquidation, maximizes the information sensitivity of the contract. This is because additional information sensitivity reduces his expected cost of financing. Maximum information sensitivity can be achieved by setting $F_{1,2}$ to its maximum value of x_2.

While Diamond (1991) shows that asymmetric information favors issuance of short-term debt, Goswani, Noe and Rebello (1995) and (1997) argue that the temporal distribution of asymmetric information may lead to a preference for long-term debt as well. In their model, entrepreneurs can be either of a good type ($\theta = G$) or a bad type ($\theta = B$), and they invest in a project with cash flows, x_t, that accrue in both $t = 1,2$. The type G entrepreneur has a higher probability of obtaining higher cash flows than a type B. Here again, only pooling equilibria obtain, in which the optimal debt structure is determined by the type G entrepreneurs. Unlike Diamond (1991), who shows that with no liquidation costs (i.e., loss of managerial private benefits) short-term debt is always optimal, Goswani, Noe and Rebello demonstrate that the optimal debt maturity structure depends on the temporal pattern of information asymmetry. Specifically, when the information asymmetry primarily regards the short-term cash flow, x_1, an entrepreneur's preference for short-term or long-term debt depends on the default risk at $t = 1$. In the absence of interim default risk (that is, if the short-term debt maturing at $t = 1$ is fully repaid), the type G entrepreneur prefers to issue short-term debt to take advantage of the favorable reduction of information asymmetry that will result at $t = 1$. If, on the contrary, the interim default risk is sufficiently large, when there is sufficiently large asymmetry information on the short-term cash flow, x_1, the information advantage of short-term debt vanishes and the type G entrepreneur prefers to issue long-term debt. When, instead, the information asymmetry primarily concerns long-term cash flows, that is, x_2, and the degree of information symmetry increases over time, the entrepreneur prefers to issue long-term debt, maturing at $t = 2$, with covenants that restrict interim dividends. In this case, the entrepreneur does not benefit from issuing short-term debt, because of the small information advantage offered when refinancing at $t = 1$. Dividend constraints allow the entrepreneur to commit interim cash flow, on which there is relatively less information asymmetry, to secure the repayment of the long-term debt.

Finally, Rajan (1992) analyzes the choice of maturity structure in the context of debt that is privately placed with informed investors (such as banks). In his model, the entrepreneur exerts a non-contractible effort, after which the investor and the entrepreneur privately observe the same signal on the final payoff. Signals can be either "good," in which case the project should be continued, or "bad," in which case the project should be liquidated. Entrepreneurs benefit from project continuation and always prefer that the project be completed. If short-term debt is used, then the investor, after observing a good signal, can extract surplus from the entrepreneur by threatening not to refinance the project. Thus, short-term debt allows the investor to hold up the entrepreneur at future refinancing dates, with a negative effect on the incentives to exert effort. If long-term debt is used, then the entrepreneur, after observing a bad signal, can extract surplus from the investor by threatening to continue the project, even if it is unprofitable for the investor. Thus, long-term debt allows the entrepreneur to hold up the investor at future dates when liquidation is efficient. In anticipation of the future surplus loss to the entrepreneur, the investor will require ex-ante a greater contractual interest rate, with a negative impact on the entrepreneur's incentives. Thus, the entrepreneur will choose ex-ante the maturity structure of debt that gives better effort incentives.

c. Collateral

In many cases, the debt contract requires the entrepreneur to pledge specific assets to a specific (class of) investor(s) as collateral for the loan. The wide use of collateral in debt contracts cannot be explained if collateral simply results in a change in default risk, and therefore in a reallocation of risk between the borrower and the existing lender. The main insight of the research that analyzes the costs and benefits of collateral is to show how collateral can affect either the moral hazard and adverse selection problem faced by the investor who lends to the entrepreneur, or the moral hazard problem faced by the entrepreneur when dealing with his investors.

One of the first papers showing the beneficial role of collateral is Stulz and Johnson (1985). This paper argues that issuing collateralized (or secured) debt can reduce the Myers (1977) underinvestment problem. As discussed in the previous section, the presence of existing debt reduces the entrepreneur's incentives to contribute further capital to the undertaking of a new investment project, because it will result in a wealth transfer to the lender. Stulz and Johnson show that the entrepreneur can reduce this wealth transfer by financing (part of) the new investment by issuing new debt collateralized by the new project's assets. Thus, the use of collateralized debt helps restore the entrepreneur's investment incentives.

Collateral is also a common feature of bank loans. Several papers show that collateral plays a key role in reducing the extent of credit rationing. Credit rationing arises in situations in which the adverse selection or moral hazard problem faced by investors is worsened by an increase of the loan's interest rate. This may happen, for example, because a higher interest rate induces high-quality entrepreneurs to drop from the market, leaving only the low-quality ones as potential borrowers, and thereby worsening the pool of loan applicants (see Stiglitz and Weiss, 1981). In these cases, investors may prefer to keep the lending interest rate to a level which is below the one necessary to clear markets.

Bester (1985), Besanko and Thakor (1987) and Chan and Thakor (1987) show that credit rationing may no longer occur in equilibrium when banks are allowed to compete by choosing both collateral and interest rates. These authors find that collateral can be used to separate good entrepreneurs from bad ones, thus eliminating the need to ration credit. The key argument is that when bank loan contracts can vary both the size of the collateral and the interest rate charged, then good entrepreneurs will self-select by choosing contracts with low interest rates but high collateral, while bad entrepreneurs will choose the contracts with high rates but low collateral.

This happens because collateral is paid in the state in which the project fails, while interest payments are made in the state in which the project succeeds. Thus, better borrowers will prefer to post collateral in return for lower interest as a way to signal their type. This in turn improves credit allocation and market efficiency. Interestingly, Chan and Thakor (1987) show that this result depends on the type of equilibrium studied. In particular, in a competitive equilibrium in which banks earn zero profits, if all rents accrue to entrepreneurs the use of collateral will eliminate credit rationing. However, if all the rents accrue to depositors, then the use of collateral will still result in some rationing in equilibrium.

Collateral may also be beneficial in avoiding inefficient liquidation. Bester (1994) shows that when project returns are only observed by the entrepreneur, the threat of liquidation provides the entrepreneur with the incentive to pay the lender. If the entrepreneur does not repay the loan, the lender can either liquidate the project or renegotiate down the debt contract. This possibility, however, gives the entrepreneur the incentive to strategically default even when returns are high enough to repay the loan. Bester shows that collateral lowers the surplus the entrepreneur obtains in the renegotiation that follows a strategic default. In the mixed strategy equilibrium, collateral is used to make these strategic defaults less likely and hence to minimize the expected deadweight costs of liquidation.

The presence of collateral also has an impact on the investors' incentives. Rajan and Winton (1995) study the impact of collateral on the incentive of lenders to monitor and liquidate (if necessary) the entrepreneur's project. They show that by giving one investor (specifically, a bank) the ability to request additional collateral upon obtaining negative information, the firm can increase the bank's incentive to monitor. This feature is beneficial because other investors free ride on banks' monitoring efforts, leading to underinvestment in monitoring. The bank's ability to request more collateral (and therefore to obtain more senior claims) increases the bank's expected returns from monitoring and therefore its incentives to monitor.

The use of collateral, however, is not always beneficial. Manove, Padilla and Pagano (2001) analyze the effect of collateral on a bank's incentives to conduct the initial screening of potential borrowers. They argue that screening and collateral are substitutes, because higher collateral reduces a bank's exposure to default risk and thus reduces its incentives to screen. Furthermore, if screening is a value-enhancing activity, then too much collateral may have a negative impact on efficiency; hence, limitations on the use of collateral may improve credit markets' efficiency. Note that in this model, competitive banks charge the correct (fair) interest rate on average and so they do not have an incentive to screen at the socially efficient level. However, in monopolistic credit markets, the bank is able to extract the entire surplus from the entrepreneur and therefore it internalizes all efficiency gains from monitoring. Thus, in this case the monopolistic bank would require lower levels of collateral and engage in the socially optimal level of screening. Collateral restrictions, then, only matter for sufficiently competitive credit markets.

Finally, Habib and Johnsen (1999) take the view, as in Aghion and Bolton (1992) and Zender (1991), that debt can be used as a mechanism to redeploy assets. They model a situation in which an asset can have two uses whose value depends on the state of nature. In the good state the assets' best use is at the hands of the entrepreneur, while in the bad state the assets' best use is at the hands of the lender. When both parties need to make asset-specific investments, ex-ante contracting via a secured debt solves the investment distortion problem. If debt is not secured, then ex-post bargaining in the bad state leads to lower incentives for the lender to invest ex-ante in identifying better redeployment opportunities. Thus, the use of collateral allows the lender to capture the entire surplus from his actions in the bad state. This arrangement, by avoiding bargaining in the state in which the lender has the best alternative use for the asset, improves the lender's incentives ex-ante, thereby improving efficiency.

d. The number of creditors

In the standard static *CSV* framework, minimization of the verification costs implies that the entrepreneur should seek financing from the smallest possible number of investors. Increasing the number of creditors may be beneficial in the dynamic setting of Bolton and Scharfstein (1990) and Hart and Moore (1989) and (1998) because it can induce the entrepreneur to make greater payment to investors. The presence of multiple investors can, in this way, effectively impose greater discipline on the entrepreneur, and it allows him to obtain financing for projects that would not be financed otherwise (thus increasing efficiency).

This possibility is examined in Bolton and Scharfstein (1996). Consider again the basic Bolton and Scharfstein (1990) setting in which the entrepreneur's assets may be partitioned into two distinct classes (for example, two separate production facilities) and each class is pledged to a distinct investor. Assets have a greater value if employed together, and if employed by the entrepreneur rather than by an external buyer. If the entrepreneur at $t = 1$ is in a liquidity default (that is, the low state is realized), he does not have the resources to pay the contractual payment to investors. In this case, investors liquidate the assets and sell them to a potential buyer. The buyer will have to pay more for the assets when they are dispersed among separate investors than when assets are concentrated in the hands of a single investor (this happens because the buyer's Shapley value is lower when he bargains with two investors). Similarly, if the entrepreneur at $t = 1$ is not liquidity constrained (that is, the high state is realized) but strategically defaults, investors will be able to extract a greater payment from the entrepreneur when assets are dispersed among several investors rather than concentrated.

Dispersing assets among several investors, therefore, has the effect of enabling investors to extract greater payments from either the entrepreneur (in the good states) or from outside buyers (in the bad states). The latter possibility, however, may backfire if it reduces the likelihood that a buyer emerges (for example, because the buyer must pay some up-front costs to acquire the necessary skills to manage the assets). This implies that low-quality entrepreneurs (with a high probability of default) should seek financing from a single source (say, a bank), while high-quality entrepreneurs (with a low probability of default) should seek financing from a large number of creditors.

The benefits of obtaining financing from a large number of investors is stressed also by Dewatripont and Maskin (1995). In this case, entrepreneurs have private information on their project's quality: good projects are completed at $t = 1$; bad projects give no payoff at $t = 1$ and are completed only at $t = 2$. The bad project's payoff may be increased by having the investor exert some effort at $t = 1$. If the entrepreneur seeks financing from only one source, the investor will exert more effort toward making the continuation of a bad project profitable. If the entrepreneur seeks financing from multiple sources, investors will be less willing to exert effort, making the continuation of a bad project unprofitable. Thus, financing from multiple investors leads to the termination of bad projects and, thus, "hardens" the entrepreneur's budget constraint and makes the entrepreneur unwilling to initiate them at $t = 0$. This implies that if bad projects are socially wasteful (that is, if they generate a negative social surplus), financing from multiple sources increases efficiency because it deters entrepreneurs endowed with bad projects from seeking financing. It also implies that a decentralized financial system, in which entrepreneurs must seek financing from several decentralized investors, may be preferable to a centralized financial system, dominated by few large investors.

Seeking financing from a large number of investors does not always allow entrepreneurs to obtain a larger amount of funds. Bris and Welch (2005) argue that having a large number of investors creates a free-rider problem among them, and the ensuing moral hazard in teams (see Holmstrom, 1982) reduces the investors' ability to recover a payment from entrepreneurs who are in financial distress. However, recovery requires investors to sustain dissipative collection costs and has a purely redistributive effect. Thus, seeking financing from a large number of investors is ex-ante desirable, since it reduces the dissipative costs of recovery. Costly concentration of financing from a small number of investors, however, can be used by good entrepreneurs to signal their value to investors, if some pre-contractual asymmetric information exists.

The number of creditors is also important when financial intermediaries, such as banks, act as relationship lenders who monitor borrowers and collect private information that can be used strategically to hold up the entrepreneur (see Rajan, 1992). Von Thadden (1994) shows that the presence of multiple banks can reduce their ex-post ability to extract rents, thereby restoring incentives. Similarly, in Holmstrom and Tirole (1997), simultaneous financing by uninformed and informed investors (i.e., banks) reduces the surplus allocated to informed investors, allowing entrepreneurs to reduce their cost of financing. Carletti (2004) shows that the presence of multiple banks reduces their incentives to overmonitor entrepreneurs. In Detragiache, Garella and Guiso (2000), financing through multiple banks reduces the chances that entrepreneurial projects are liquidated due to a bank's liquidity crunch. In Carletti, Cerasi and Daltung (2006), multiple-bank lending allows banks to finance more independent projects, increasing diversification and, thus, monitoring incentives. Further discussion of the specific role of banks as investors is beyond the scope of this chapter and is analyzed elsewhere in this handbook.

7. Concluding remarks

In this chapter we have considered the problem faced by an entrepreneur seeking to raise capital in competitive markets to finance a project. We have taken a very narrow view, examining the circumstances in which the optimal security issued by the entrepreneur has the structure of a debt contract. Our main focus has been on the role of certain specific contractual features that usually characterize debt contracts, such as seniority, maturity and the use of collateral. While discussing the choice of seeking financing from a single investor as compared to a larger number of investors, we have deliberately ignored other important issues, such as the role of bank debt versus publicly traded debt; financial distress and the role of debt renegotiation before and during bankruptcy; the role of other contractual features, such as call and conversion options; and more complex security design issues.

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