4

Some Determinants of Borrowing Capacity

4.1 Introduction: The Quest for Pledgeable Income

This chapter refines the analysis of Chapter 3 by analyzing several factors that increase or reduce the ability to borrow. The fixed-investment variant of Section 3.2 taught us that socially worthwhile projects may not be undertaken because the investors can only be offered a piece of the total cake. Thus, they are reluctant to get involved if they have to finance a major portion of the outlay. The variable-investment variant of Section 3.4 hinted at a theme that will recur throughout this book: for contracting choices of interest,[1] there is a tradeoff between value (social surplus, NPV) and pledgeable income (value to investors). An entrepreneur is willing to sacrifice value to raise pledgeable income and thereby secure financing. The total size of the cake is thereby reduced, but if the fraction of the cake that is returned to investors is increased sufficiently, financing becomes more likely. The quest for pledgeable income took a simple form in Section 3.4, namely, a limit on the scale of investment, but the principle of a sacrifice of value to boost pledgeable income will be seen to have broad applicability and to explain a number of our financial institutions. The chapter offers some first illustrations.

Section 4.2 offers a simple presentation of the diversification argument, that is, the possibility for the borrower to pledge her payoff on a project as "collateral" for another, independent project. Such "cross-pledging" can be achieved either through a contract in which the former claim is promised as collateral to the holders of liabilities in the latter project, or by integration of the activities within a single firm, in which liabilities are not "earmarked" to a specific division, but rather joint to all divisions. We analyze the conditions under which diversification alleviates the incentive problem and point at some limits to diversification.

Section 4.3 studies the pledging of real assets as a (partial) guarantee enjoyed by the investors in the case of default. It identifies some factors that make some assets good collateral and studies costs associated with the use of physical assets as collateral. It shows, in particular, that collateral should generally be pledged contingent on poor performance, and that borrowers with weak balance sheets should pledge more collateral if the relationship between borrower and lenders is fraught with moral hazard.

Section 4.4 analyzes the optimal liquidity of the entrepreneur's stake in the firm. Intuitively, letting the entrepreneur cash in earlier rather than later creates a valuable option value: it may be that the entrepreneur faces profitable investment opportunities in new projects or that she needs money for personal reasons before the outcome of the project is realized. A liquid entrepreneurial claim thus raises value; however, by giving the entrepreneur a chance to exit before the performance in the project is known increases the agency cost and therefore reduces the pledgeable income. Section 4.4 investigates the circumstances under which the entrepreneur's claim can indeed be made liquid.

Section 4.5 shows that borrowing may be hampered if the borrower can force renegotiation of the initial loan agreement by threatening not to complete the project. This potential "holdup" problem is particularly serious when the entrepreneur is indispensable to the completion of the project, and when her outside opportunities have become attractive relative to her inside prospects.

1. The choice would be a no-brainer if a contractual choice increased both the value and the pledgeable income relative to another contractual choice: the increased pledgeable income would facilitate financing, and the increased value, which, recall, is appropriated by the borrower under competitive lending, would be more attractive to the borrower.

Lastly, the supplementary section investigates the rationales for group lending, which turn out to be closely related to some of the themes of this chapter. The supplementary section argues that group lending may be an attempt either to use social capital as collateral or to use peer monitoring in order to reduce agency costs.

4.2 Boosting the Ability to Borrow: Diversification and Its Limits

The computation of the equity multiplier in Section 3.4 was conducted under the assumption that the probability of success is independent of the scale of the investment. As we will observe, this implicitly assumed that if an expansion in the scale of "the project" actually stands for an increase in the number of projects, then the projects' outcomes are perfectly correlated (conditional on the effort that is exerted on them).[2] This formalization depicted a polar case in which there are no benefits to diversification.

2. One way to think about the case of perfect correlation is to introduce a latent random variable ω that is, say, uniformly distributed on $[0, 1]$ and that is realized after the borrower's choice of efforts on the various projects. If $0 \leqslant \omega < p_L$, then a project succeeds even if the borrower shirked on the project. If $\omega \geqslant p_H$, a project fails even if the borrower worked on the project. Lastly, if $p_L \leqslant \omega < p_H$, a project succeeds if and only if the borrower worked on the project. Note that the latent variable is the same for all projects.

The model with multiple projects with sizes $I_1, \dots, I_n$ and private benefits $B_1, \dots, B_n$ can then be shown to be equivalent to a model with a single project with size $I = \sum_i I_i$ and private benefit $B = \sum_i B_i$. Heuristically, the pledgeable income is the same in the case of multiple projects and of a single, large project.

The reader might intuit that the borrower has more leeway for misbehavior in the case of multiple projects, as she has other alternatives (shirk on some projects and work on others) to working on all projects than shirking on all projects. This intuition, however, is misleading because these "partial deviations" are perfectly detected whenever they might be beneficial. Indeed, suppose $\omega < p_L$ (respectively, $\omega \geqslant p_H$). Then all projects succeed (respectively, fail) regardless of effort and the borrower would be better off shirking on all projects. And if $p_L \leqslant \omega < p_H$, some projects succeed and some fail, proving unambiguously that the borrower has deviated from the strategy of zealousness on all projects. Thus, if the borrower receives nothing in such situations, the best strategy for the borrower is, as in the case of a single project, either to work (on all projects) or to shirk (on all projects). Even with multiple projects, there is a single relevant incentive constraint (work or shirk).

In contrast, the case of independent projects can be represented by a set of independent random variables $\{\omega_i\}_{i=1,\dots,n}$ with the same distribution as ω.

However, as Diamond (1984) has forcefully argued,[3] diversification may bring substantial incentive benefits when projects are independent. Intuitively, the borrower can *cross-pledge* the incomes of various projects. That is, she can use the income she receives on a successful project as *collateral* for other projects. Such cross-pledging is useless when projects are correlated, because, when a project fails, the collateral posted for this project (the income from other projects) is valueless.

We analyze the incentive benefits from diversification in the cases of two independent projects and of a large number of such projects.[4] We then point at some limits to the diversification argument.

4.2.1 The Benefits of Diversification: The Case of Two Projects

Let us consider two independent and identical projects with fixed investment size I. That is, the two projects are as described in Section 3.2. Projects succeed (yield R) or fail (yield 0). The probability of success is p_H if the entrepreneur behaves (but then receives no private benefit) and p_L if she misbehaves (and receives private benefit B). Let $2A$ denote the entrepreneur's initial wealth, that is, A per project. The borrower is risk neutral and protected by limited liability. The lenders are risk neutral and demand an expected rate of return equal to 0.

If both projects are funded, then the borrower can work on both, shirk on both, or work on either of them. There can also be four outcomes: both projects succeed, they both fail, or only one of them succeeds. It is clear that two projects are undertaken only if the incentive scheme induces the borrower to work on both projects. Otherwise, the borrower would be better off undertaking one project or none.

4.2.1.1 Project Financing

Let us begin with the benchmark of stand-alone financing for each project. Project financing refers to the provision of funding for a given, well-identified project. The analysis is then that of Section 3.2 for

3. See, for example, Cerasi and Daltung (2000), Matutes and Vives (1996), Williamson (1986), and Yanelle (1989) for contributions that make use of Diamond's argument.

4. Similar expositions of the Diamond argument can be found in Holmström (1993) and Hellwig (2000).

each project taken in isolation. The borrower receives R_b in the case of success and 0 in the case of failure of a given project, independently of what happens in the borrower's other activity. As usual, the incentive constraint for a given project is

$$(\Delta p)R_b \geqslant B,$$

and the per-project financing condition is that the pledgeable income exceeds the investors' initial outlay:

$$p_H\left(R - \frac{B}{\Delta p}\right) \geqslant I - A$$

or

$$A \geqslant \bar{A}.$$

This condition can be interpreted as a capital or net worth requirement. If $A < \bar{A}$, project financing is not viable.

Note that project financing does not make full use of the borrower's potential liability. When project 1, say, fails, then with conditional probability p_H (which is the prior probability under statistical independence of the two projects), project 2 is successful and returns R_b to the entrepreneur. Even under limited liability the entrepreneur's income on the first project can be brought down to $[-R_b]$ (conditional on the second project succeeding) rather than 0. We now make use of this observation.

4.2.1.2 Cross-Pledging

Let us now bring the two projects under a single roof (a "firm"), or at least allow joint liability between the two projects, so that the income on one project is used as collateral for the other project. Let R_2, R_1, R_0 denote the borrower's reward when the number of successful projects is 2, 1, 0, respectively. A risk-neutral borrower cares only about her expected reward, and thus the loan agreement should be structured so as to provide the borrower with maximal incentives for a given expected reward

$$p_H^2 R_2 + 2p_H(1 - p_H)R_1 + (1 - p_H)^2 R_0.$$

Intuitively, this requires that the borrower be rewarded only when the two projects are successful, namely, $R_2 > 0$, $R_1 = R_0 = 0$ (or, more precisely, there always exists *one* optimal incentive scheme which rewards the borrower only in the case of full success). Showing this formally is a simple exercise, which we leave to the reader,[5] who can also consult Section 4.7 for a closely related result. Note that $R_1 = 0$ corresponds to full cross-pledging (contrast this with project financing, under which $R_1 = R_b > 0$, where R_b is the entrepreneur's compensation in the case of success in a given project).

Taking this feature of the incentive scheme for granted, the condition that guarantees that the borrower prefers to work on both projects to working on neither is

$$p_H^2 R_2 - 2B \geqslant p_L^2 R_2$$

or

$$(p_H + p_L)R_2 \geqslant 2\frac{B}{\Delta p}. \tag{4.1}$$

Note that this condition implies that the borrower also prefers to work on both projects to working on a single one: by shirking on the second project, say, the borrower reduces the probability of full success by p_H (the probability that the first project succeeds) times Δp (the reduction in the second project's probability of success). And thus the second incentive constraint can be written as

$$p_H(\Delta p)R_2 \geqslant B. \tag{4.2}$$

Since $p_H > \frac{1}{2}(p_H + p_L)$, this second constraint (4.2) is automatically satisfied if the first, (4.1), is.

Let us now compute the expected pledgeable income. It is equal to the expected return on the projects, $2p_H R$, minus the minimum expected payoff to the borrower, $p_H^2 R_2$, that is consistent with incentive compatibility. From (4.1) the latter is

$$p_H^2 R_2 = \frac{2p_H^2 B}{(p_H + p_L)\Delta p} = 2(1 - d_2)\frac{p_H B}{\Delta p},$$

5. There are two incentive constraints. First, the borrower must prefer to work on both projects to working on a single one, and so

$$\begin{aligned} &p_H^2 R_2 + 2p_H(1 - p_H)R_1 + (1 - p_H)^2 R_0 - 2B \\ &\qquad \geqslant p_H p_L R_2 + (p_H + p_L - 2p_H p_L)R_1 + (1 - p_H)(1 - p_L)R_0 - B. \end{aligned}$$

She must also prefer working on both projects to working on none, and so

$$\begin{aligned} &p_H^2 R_2 + 2p_H(1 - p_H)R_1 + (1 - p_H)^2 R_0 - 2B \\ &\qquad \geqslant p_L^2 R_2 + 2p_L(1 - p_L)R_1 + (1 - p_L)^2 R_0. \end{aligned}$$

It then suffices to show that for a given $\{R_2, R_1, R_0\}$ satisfying these two inequalities, there exists R_2' such that $\{R_2', 0, 0\}$ also satisfies the two inequalities and provides the entrepreneur with the same expected compensation:

$$p_H^2 R_2' = p_H^2 R_2 + 2p_H(1 - p_H)R_1 + (1 - p_H)^2 R_0.$$

where

$$d_2 \equiv \frac{p_L}{p_L + p_H} \in (0, \tfrac{1}{2})$$

is an agency-based measure of economies of diversification into two independent projects. Letting $2A$ denote the borrower's initial net worth (so, A is her per-project cash on hand), the two projects can be funded if

$$2p_H R - 2(1 - d_2)\frac{p_H B}{\Delta p} \geqslant 2I - 2A,$$

or

$$p_H\left[R - (1 - d_2)\frac{B}{\Delta p}\right] \geqslant I - A, \tag{4.3}$$

or

$$A \geqslant \bar{\bar{A}}, \quad \text{with } \bar{\bar{A}} \equiv I - p_H\left[R - (1 - d_2)\frac{B}{\Delta p}\right] < \bar{A}.$$

Thus, cross-pledging facilitates financing.

Role of correlation. The benefits from cross-pledging come from the diversification effect. We have assumed that projects were independent. Suppose, in contrast, that the two projects are perfectly correlated. Then, condition (3.3) implies that they can both be funded if and only if

$$p_H\left[R - \frac{B}{\Delta p}\right] \geqslant I - A \quad \text{or} \quad A \geqslant \bar{A}.$$

In words, there is no cost to project financing if projects are perfectly correlated. Or, put differently, the effect of diversification, that is, of the independence of the two projects, is tantamount to a reduction of the private benefit from B to $(1 - d_2)B$. Because of the independence of the two projects, the borrower can pledge his income on a project as collateral for the other project, were the second project to fail. Thus *project finance*, namely, a mode of financing that establishes (unrelated) claims on individual projects, *is here suboptimal* unless $d_2 = 0$, that is, unless there are no economies of diversification. We refer to Exercise 4.4 for the study of arbitrary (positive or negative) correlation between the two projects.

Variable investment size. In the case of fixed investment sizes, the benefit from diversification takes the form of a facilitated access to financing. Conditional on getting financing, the total NPV $(2(p_H R - I))$ is, of course, unchanged. With variable investment sizes, the extent of financing, rather than the access to financing, is the issue. Then diversification increases the borrowing capacity and therefore the NPV (see Exercise 4.10).

4.2.2 The Benefits of Diversification: A Large Number of Projects

The previous diversification result extends straightforwardly to n independent projects.

For the purpose of this section, let us assume that

$$p_H R - I < B.$$

The reader will check that a borrower with net worth nA can finance the n projects if and only if

$$p_H\left[R - (1 - d_n)\frac{B}{\Delta p}\right] \geqslant I - A. \tag{4.4}$$

where

$$d_n = \frac{p_L(p_H^{n-1} - p_L^{n-1})}{p_H^n - p_L^n}$$

increases with n (note that $d_1 = 0$). In the limit as n tends to infinity, d_n converges to p_L/p_H and the financing condition converges to

$$p_H R - B \geqslant I - A. \tag{4.5}$$

That is, in the limit the pledgeable income per project is equal to $p_H R - B$. Intuitively, with a large number of independent projects, shirking on a nonnegligible fraction of projects is necessarily detected by the law of large numbers. And so the highest rent that the entrepreneur can grab is her private benefit B on each project.

In this model, increasing the number of projects raises the pledgeable income per project and alleviates incentive problems, but does not fully eliminate credit rationing. Recall that positive-NPV projects satisfy $p_H R \geqslant I$ and that we assumed that

$$p_H R - I < B.$$

For a given total net worth of the borrower, her net worth per project A tends to 0 as n tends to infinity and thus (4.5) is violated. In other words, a borrower with a finite net worth cannot undertake an arbitrarily large number of positive-NPV projects. Thus net worth still plays a role even with a large number of projects.

In contrast, Diamond (1984) showed that a borrower who can avail herself of a large number of projects is never credit rationed, and thus faces no capital (or leverage) requirement. Where does this discrepancy in results come from? Here the borrower can always divert nB in private benefits. So, her rent necessarily grows proportionally with the number of projects.

Alternatively, we could have assumed away private benefits and called B the disutility of working on a project, with the disutility of shirking being normalized at 0. In this "Diamond formulation," a project has positive NPV if $p_H R \geqslant I + B$, as the disutility of effort must be counted as a cost of the project. (In contrast, in the basic formulation the borrower does not take her private benefit.) The incentive conditions remain the same as in the private benefit model, and thus the only difference between the two formulations is the definition of a positive-NPV project. Condition (4.5) then shows that in the Diamond formulation, the borrower can undertake an arbitrarily large number of positive-NPV projects provided that her cash on hand is nonnegative.

This unboundedness and the related lack of capital requirement differentiate the Diamond formulation from the one considered here. But the main message—diversification boosts borrowing capacity—is the same in both formulations.

Remark (optimality of the standard debt contract). Diamond shows that a *debt contract* with investors achieves the social optimum with a large number of projects. Suppose (somewhat informally) that in our formulation (i) there is a continuum of independent projects and (ii) $p_H R - I > B$, so we are in a situation in which the borrower can undertake an infinite number of projects without any initial net worth. Assume indeed that the borrower has no initial net worth ($A = 0$), and let the borrower issue a debt contract in which she must reimburse $D = I$ (we normalize the mass of projects to one). Investors are willing to purchase this debt claim if and only if the probability of default is equal to 0.

Let us first check that the borrower prefers behaving on all projects to shirking on all. The "law of large numbers"[6] implies that the firm's total income is $p_H R$ in the former case and $p_L R$ in the latter case. As $p_H R > I > p_L R$, the borrower's residual claims are $p_H R - I$ and 0, respectively. So, the borrower prefers working on all projects if and only if $p_H R - I > B$, which we have assumed in order to guarantee that the borrower needs no capital to undertake a large number of projects.

More generally, it is easy to check that the borrower does not benefit from working on a fraction of projects and shirking on the remaining fraction. Suppose the borrower works on a fraction κ of projects. Either $\kappa p_H R + (1 - \kappa) p_L R < I$, and then there is default and the borrower would be better off shirking on all projects; or $\kappa p_H R + (1 - \kappa) p_L R \geqslant I$, and then

$$\frac{\mathrm{d}}{\mathrm{d}\kappa}[\kappa p_H R + (1 - \kappa)(p_L R + B)] = (\Delta p) R - B > 0,$$

and so, if $\kappa < 1$, the borrower, who receives the firm's incremental income once debt is fully reimbursed, is better off increasing κ.

The logic of the argument is clear: a debt contract makes the borrower *residual claimant* of profits whenever there is no default. So she has proper incentives to work as long as she does not choose to default (we employ "choose" on purpose, because the law of large numbers implies that there is no surprise as to whether default occurs).

4.2.3 Limits to Diversification

While the point that diversification can alleviate incentive problems and lower capital requirements is an important one, it should be realized that there are in practice a number of obstacles to diversification.

Endogenous correlation. The key to the diversification argument is that projects are independent, so that if one fails another is still likely to succeed and the latter's income is thus good collateral for the former. An important implicit assumption of the diversification argument is that the borrower cannot alter the independence through project choice; for, the borrower has an incentive to choose correlated projects ("asset substitution"). Intuitively, the correlation destroys the value of "collateral," and cross-pledging then is useless.

To illustrate this, consider the contract obtained in the case of two projects

$$\{R_2 = 2B/[(\Delta p)(p_H + p_L)],\ R_1 = R_0 = 0\}.$$

Suppose that the manager can choose two independent projects or two perfectly correlated projects,

6. Interpreted very loosely. See Diamond (1984) and Hellwig (2000) for more careful treatments, with a finite number of projects going to infinity.

but that the investors are unable to tell whether the projects are independent or correlated. By choosing correlated projects rather than independent ones, the borrower obtains

$$U_b^c = p_H R_2 > U_b^i = p_H^2 R_2,$$

where "c" stands for "correlated projects" and "i" for "independent projects," and so diversification does not occur.

This point, which is related to the discussion of "asset substitution" in Chapter 7, should not surprise the reader. The borrower's claim is an equity claim, and is therefore convex in realized income. The borrower's incentive structure makes her risk loving (even though her intrinsic preferences exhibit risk neutrality). Under correlation, the probabilities of 2, 1, and 0 successes are $(p_H, 0, 1 - p_H)$, while they are $(p_H^2, 2p_H(1 - p_H), (1 - p_H)^2)$ in the case of independent projects. Correlation therefore induces a mean-preserving spread of the distribution. And, as is well-known, risk lovers benefit from a mean-preserving spread.

Similarly, consider Diamond's debt contract, which, recall, implements the optimum with a large number of projects. Assume again that the borrower can choose between independent projects and correlated projects. Then

$$U_b^c = p_H(R - I) > U_b^i = p_H R - I,$$

so the borrower prefers correlation.

The theoretical concern expressed here underlies much of corporate risk management and of prudential reforms attempting to measure a bank's "value at risk." The covariance among activities of a firm or of a financial institution such as a bank, or of a division thereof, is often hard to measure. Financial innovation, in particular the development of derivatives, such as swaps, futures, and options, has created new opportunities for insurance against external shocks (such as interest rate or exchange rate shocks). This in principle should alleviate incentive problems by protecting managers from shocks they have no control over and thereby making them more accountable.[7] On the other hand, derivatives and other financial products can be used in the opposite direction to *increase* rather than decrease risk; and it often proves difficult for outsiders to estimate the risk pattern of a firm's or a division's portfolio. Consequently, boards of directors or chief executive officers are concerned about a division or a trader losing fortunes through nondiversified portfolios. Similarly, bank depositors (or rather their representatives, namely, the banking supervisors) are worried about failure of nondiversified banks and have been actively designing methods for measuring the riskiness of a portfolio so as to better tailor capital requirements to this riskiness.

Core business competency. Another obvious obstacle to diversification is that the borrower often has expertise only in limited sectors. Expanding within the realm of the core business may not substantially improve diversification as new activities are subject to the same industry-wide shocks as existing ones. On the other hand, diversification outside the core business activities generates inefficiencies (which can easily be modeled in our framework by introducing, say, new and independent projects with increasing stand-alone capital requirements).[8] In such situations, diversification need not boost debt capacity.

Limited attention. To the extent that diversification goes together with an increase in the number of projects, there is some concern that the borrower cannot handle that many projects. The borrower can, of course, expand and delegate the supervision of these projects to other agents, but this introduces further agency problems. Therefore, there exists a cost to diversifying through expansions.[9]

Remark (the diversification discount). A number of empirical studies, starting with Wernerfelt and Montgomery (1988), have shown that diversification

7. See Holmström (1979), Shavell (1979), as well as Section 3.2.6. Loosely stated, the "sufficient statistic theorem" states that an agent's reward should depend only on variables over which she has control.

8. A number of observers believe that the diversification of the U.S. Savings and Loans away from residential mortgages and toward commercial real estate, instalment loans, credit card loans, and corporate securities increased rather than decreased their probability of failure (this diversification was allowed by regulators in the early 1980s in response to the serious hardships then faced by the S&Ls).

9. There is a large literature on the "span of control" and the incentive cost associated with bigger hierarchies. See, for example, Calvo and Wellisz (1978, 1979), Aghion and Tirole (1997), and the references therein.

is associated with low firm value. This observation raises questions about the direction of causality (is diversification the cause of the diversification discount?) and, relatedly, as to why diversification is still so widespread despite the popularity of refocusing. Is diversification the outcome of inefficient empire building and, if so, why are boards of directors and shareholders so complacent toward managerial recommendations in this respect? Or do diversified firms simply differ from specialized ones in a number of characteristics, as several studies have indicated? For example, Villalonga (2004a,b) shows that diversified firms are present in industries with a low Tobin's q[10] and have a lower percentage of their stock owned by institutions and insiders; she argues that the diversification discount cannot be attributed to diversification itself.

We have little to say about the possibility of empire building at this stage of the book.[11] More generally, the Diamond argument is too simplistic to address the empirical evidence regarding diversification; yet it is interesting to look at its consequences. Its logic implies that it is silent about the return expected by uninformed investors: the latter receive the market rate of return regardless of the entrepreneur's diversification decision. So a diversification discount, if any, must apply to total investor shares, which in this barebones model, also include the entrepreneur's shares (or insiders' and informed investors' shares in a broader model). Consider moving from one project to two in the model above. There are several reasons why the added project may reduce profitability: the second project may have a lower return than the first (for instance, the payoff in the case of success is lower: $R_2 \leqslant R_1$; this is the core business competency argument); the avoidance of asset substitution requires costly monitoring (endogenous correlation argument); or the second project may divert managerial attention from the first (limited attention argument). In each case, the second project reduces average profitability, and yet the entrepreneur may want to undertake it if she has enough funds or the agency cost is low enough.[12] While this exercise shows how a diversification discount may arise from corporate heterogeneity rather than a poor investment pattern, it is somewhat unsatisfactory as it misses the broader discussion of the various relevant dimensions of heterogeneity that would be needed for both a better theoretical understanding of diversification and a more structured estimation of the discount and its underpinnings.

4.2.4 Sequential Projects: The Build-up of Net Worth

Section 4.7, in the supplementary section, investigates the case of a sequence of two projects, project 1 at date 1 and project 2 at date 2.[13] The key difference with the case of two "simultaneous projects" analyzed in Section 4.2.1 is that the outcome (success or failure) in the first project is realized before the investment in the second project needs to be sunk. The new feature is that the investment in the second project can be made contingent on the first project's outcome. In particular, the optimal contract may threaten the entrepreneur with nonrefinancing if the first project fails even though the projects are independent and so there is no learning about the second project's profitability from first-period performance. In the (constant-returns-to-scale) variable-investment context, the main results of that section can be summarized in the following way:

(i) The entrepreneur cannot do better through long-term contracting than entering a sequence of short-term contracts in which the investors are reimbursed only on the current project and break even in each period (no cross-pledging). The entrepreneur receives nothing and does not invest in the second project if she fails in the first period.

10. Tobin's q is equal to the market value of a firm's assets divided by the replacement value of these assets.

11. Managerial rents do grow with firm size in our model, suggesting that the borrower would push for a larger empire. The question is therefore why investors would let the borrower sacrifice investor value to increase her own managerial rent. In Chapter 10, we will discuss reasons why managers often get their own way.

12. It is, furthermore, easy to build examples in which diversified firms have a lower percentage of stocks held by insiders (due to the fact that they have to borrow more).

13. The analysis carries over to an arbitrary number of projects.

(ii) The first-period investment is larger than it would be in the absence of a follow-up project. The threat of not being able to finance the second project acts as disciplining device and alleviates date-1 moral hazard. Put differently, the fact that \$1 of entrepreneurial net worth at date 2 is worth more than \$1 to the entrepreneur due to credit rationing makes the entrepreneur more eager to behave at date 1.

(iii) Stakes are increasing: the date-2 investment in the case of date-1 success is larger than the date-1 investment.

(iv) The entrepreneur has a higher utility in the sequential-project case, as the lower agency cost boosts borrowing capacity.

(v) Project correlation need no longer reduce the entrepreneur's utility due to a learning effect: the second-period project's dimension can be made contingent on the first-period outcome, which is then informative about the date-2 prospects.

4.3 Boosting the Ability to Borrow: The Costs and Benefits of Collateralization

In the previous sections, "assets" or "net worth" referred to some form of cash that the borrower was able to put up front to defray part of the cost of investment. Some other assets cannot be used up front to participate in the financing, and yet are "quasi-cash." Suppose for instance that the entrepreneur has no cash but, as a leftover of a previous activity, will deliver some accounts receivables to a buyer, resulting for the entrepreneur in riskless profit A. So total profit will be $R + A$ in the case of success of the current project and A in the case of failure. Obviously, the entrepreneur can pledge this riskless profit A to the lenders, and everything is *as if* the entrepreneur had cash A today. Or, to emphasize the same point, suppose that the entrepreneur has no cash today, but that the investment I is used to purchase equipment or commercial real estate, that is used for the project and will after completion of the project be resold at some riskless price A. This resale value can be pledged as collateral to the lenders and is quasi-cash.

More generally, the ability to pledge productive assets may help raise external finance. This section makes a few points concerning the link between collateral and loan agreements.

4.3.1 Redeployability

We start with the straightforward point that the option to use a productive asset for other purposes outside the firm helps raise external finance. Suppose that we extend the fixed-investment framework of Section 3.2 to allow for the possibility of learning that the investment could have superior alternative uses. More precisely, let I be spent to purchase some productive asset such as land or equipment. After the investment is sunk but before the entrepreneur starts working on the project, a public signal accrues that indicates whether the project is viable:

- with probability x, the project is viable and its characteristics are as described in Section 3.2 (so, the model of Section 3.2 corresponds to $x = 1$);
- with probability $1 - x$, the parties learn that the project will not deliver any income (at least under current management), regardless of the entrepreneur's effort (for example, there might turn out to be no demand for the corresponding product or perhaps the entrepreneur will prove to be an incompetent manager of the assets).

In the second situation, labeled "distress," the asset can be sold to a third party at some exogenous price $P \leqslant I$ (this value of collateral in the case of distress is here taken as exogenous: see the discussion below). A high resale price P corresponds to a highly redeployable asset. By contrast, a specialized asset should fetch a low resale price. Commercial real estate is one of the most redeployable assets, even though resale implies a loss. At the opposite extreme lie highly specific investments such as a die (or, more generally, custom-made equipment) or the personnel's human capital investment into the project. Some equipment with well-organized second-hand markets, such as buses and airplanes, may lie in between.

The timing of this extension of the basic model is summarized in Figure 4.1.

With a positive probability of distress ($x < 1$) and with asset specialization ($P < I$), the condition for a

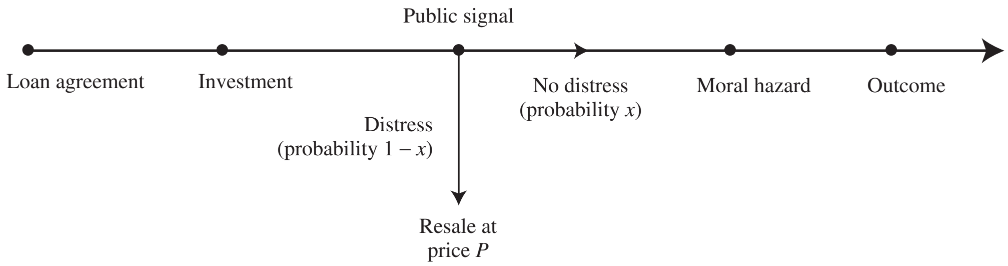

Figure 4.1

positive NPV becomes more stringent,

$$xp_{\mathrm{H}}R + (1-x)P > I,$$

and thus condition (3.1) becomes

$$x(p_{\mathrm{H}}R - I) > (1-x)(I-P). \tag{4.6}$$

That is, the expected profit must dominate the expected capital loss associated with distress. An increase in redeployability, that is, a decrease in the resale discount, $I-P$, of course, makes it more likely that the project be a positive-NPV one.

Assuming (4.6) holds and turning to the lenders' credit analysis, we compute the pledgeable income. Obviously, *it is optimal to pledge the full amount of the resale price in the case of distress to the lenders before committing part of the income R obtained in the case of success.* This results from the fact that pledging the resale value has no adverse incentive effect,[14] while profit sharing reduces the entrepreneur's stake when there is no distress. Accordingly, one possible interpretation of what happens in distress is that the firm goes bankrupt and the lenders seize the collateralized asset.

A necessary and sufficient condition for the project to be funded (the modification of condition (3.3)) is that the pledgeable income exceed the lenders' initial outlay:

$$xp_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right) + (1-x)P \geqslant I - A. \tag{4.7}$$

The threshold asset level $\bar{A}$, above which the project is funded, is given by condition (4.7) satisfied with equality; it decreases with the redeployability of the asset (as stressed, for example, in Williamson (1988)).[15] That redeployability of assets helps a firm to borrow may explain why a Silicon Valley firm has a hard time borrowing long term and borrows at high spreads over comparable-maturity Treasuries when it can borrow, while a gas pipeline company can borrow more easily and at much lower spreads.

4.3.2 Equilibrium Determination of Asset Values

The analysis of the previous subsection took the resale price P as given. One can broaden the study by investigating the demand side (who are the buyers?) and equilibrium considerations (how is the demand P determined by the interaction of supply and demand in the second-hand asset market?). Several important themes emerge from this broader agenda.

Fire sale externalities and the possibility of surplus-enhancing cartelization. Suppose that multiple firms want to put similar assets on the market when in distress. The competition between them brings down the price P. This has two effects. First, for a given investment level, assets fetch a lower price in the case of distress and so are less valuable than if a single firm disposed of its assets. This is the familiar profit-destruction effect of competition. Second, and more

14. Actually, it would even have a positive incentive effect if the entrepreneur could influence the probability of distress (which is exogenous here).

15. Furthermore, $\bar{A}$ increases with the probability of distress as long as the resale price does not exceed the pledgeable income ($P \leqslant p_{\mathrm{H}}(R - B/\Delta p)$). (Checking the validity of the assumption requires an equilibrium model of the determination of P (see, for example, Chapter 14).)

The ability to resell the asset at a high price here boosts borrowing capacity. This need not always be so if the lenders cannot prevent the borrower from reselling the assets. The borrower may then be more tempted to sell the asset in order to consume the proceeds or finance new, possibly negative NPV, investments if the asset fetches a high resale price (see, for example, Myers and Rajan 1998). Checking whether the asset is not resold for such purposes may be more difficult for assets that may need to be traded for portfolio reasons. (In Chapter 7, we will discuss a different, but related, theme called asset substitution.)

interestingly, the reduction in resale value aggravates credit rationing, and so investment declines. While the first effect, around the competitive equilibrium, amounts to a transfer between sellers and buyers, the latter effect creates a reduction in total surplus.

This raises two issues. First, could the firms not gain from colluding *ex ante* and committing to put only a fraction of the distressed assets on the market? This restraint has a cost and a benefit for the firms. The cost is that they lose the resale price on the distressed assets that they withhold. The benefit (which is a cost to buyers) is that withholding raises the market price P. It turns out that, in the case of a large number of firms and under the maintained hypothesis that assets kept in a distressed firm are worthless, firms are better off cartelizing (i.e., agreeing on a policy of restraint) if and only if the elasticity of demand for the assets is greater than 1.

Second, could cartelization increase total social surplus (buyers' surplus plus sellers' surplus)? In the absence of credit rationing, the answer would be an unambiguous "no": at the margin 1 unit of withheld assets has value $P > 0$ to the buyer and has opportunity cost 0 for the seller (since there is no alternative use of the assets inside the firm). Thus, any withholding would involve a deadweight loss. Not necessarily so under credit rationing: as we noted, the investment expansion creates economic wealth. Total surplus increases, if (fixing the pledgeable income) the NPV is sufficiently large, that is, if the agency cost (measured by the difference between the NPV and the pledgeable income) is large, and the elasticity of demand exceeds 1. This result, as well as that on the elasticity of demand, is demonstrated in Exercise 4.16.

Before connecting those results to a standard debate, though, let us issue the following caveat. Even when cartelization increases total surplus, it does not generate a Pareto-improvement. Indeed, buyers suffer from the increase in price in the resale market. This raises the issue of whether cartelization is an efficient policy to redistribute income toward the corporate sector. The general point illustrated here is that under credit rationing the marginal investment has high profitability, and so any policy that boosts pledgeable income has the potential to increase total surplus. Another such policy consists in subsidizing investment; while it may create moral hazard, it does not lead to an *ex post* inefficient allocation of assets, unlike cartelization. So, even if one ignores distributional issues and focuses on total surplus maximization, boosting pledgeable income may conceivably be achieved through less costly public policies than allowing cartelization.

The deflationary impact of simultaneous sales of assets by firms in distress is sometimes evoked in the context of banking and financial intermediation. During a severe recession, banks and other financial intermediaries often dispose of their assets (real estate, securities, etc.), which lowers the price that they can demand for these assets.[16] For example, it is not uncommon for commercial real estate in big cities to rapidly lose half of its value as a result of fire sales by financial intermediaries. Unsurprisingly, the latter sometimes attempt (perhaps with the help of the central bank as a cartel ring master) to reduce their asset sales in a concerted manner. As we have noted, this strategy pays off only when the elasticity of demand for the relevant assets is sufficiently large.

Corporate mergers and acquisitions markets. The discussion so far has ignored the fact that the buyers of assets are often themselves corporations. Thus buyers and not only sellers face financial constraints. This raises the question of whether the buyers have enough "financial muscle" to purchase the assets.

Another set of issues relates to the possibility that there may be few buyers. Put differently, the equipment, buildings, or intellectual property portfolio of the firm in distress may be exploitable by and therefore of interest to only one or a couple of potential buyers. The resale price is then determined through bargaining.

We treat these issues and others in Chapter 14.

4.3.3 The Costs of Asset Collateralization

As discussed in Section 4.3.1, pledging assets helps the borrower raise funds. Yet, the discussion there was incomplete in that there was no real difference between the firm's *ex post* income and the *ex post*

16. The consequence may be a lower ability to borrow *ex ante*, as formalized above, or a shortage of liquidity, as formalized in Chapter 5.

value of its assets, except for the fact that the assets had value even when income was low. Indeed, the borrower and the lenders had the same marginal rate of substitution between assets and cash; in other words entitlements to cash and to assets were substitute means of transferring income back to the lender. The optimal policy took the form of a pledging of assets rather than income to the lenders: incentive considerations require punishing the borrower in the case of poor performance, and so if poor performance means no or little income, the only possible punishment is the seizing of the assets.

But, somehow, we ought to come up with a *cost* of pledging assets as well as a benefit. In this respect the literature on credit rationing has emphasized that assets may have a lower value for the lenders than for the borrower (Bester 1985, 1987; Besanko and Thakor 1987; Chan and Kanatas 1985).[17] There are at least seven broad reasons for the existence of a deadweight loss attached to collateralization.

(i) There may be *ex ante* and *ex post transaction costs* involved in including liens into loan contracts, in recovering the collateralized assets in default, and in selling the asset to third parties (writing costs, brokerage fees, taxes, or judiciary costs). For example, countries differ in the efficiency and honesty of their courts. Slow trials and uncertainty about how much lenders will recoup in the judiciary process may make them discount the value of collateral, reducing both the borrower's ability to raise funds, and destroying value even if the borrower succeeds in securing a loan.[18]

(ii) The borrower may derive *benefits from ownership* that a third party would not enjoy. For example, the borrower may attach sentimental value to her family house that is mortgaged. Similarly, for a piece of equipment, the borrower may have acquired through *learning by doing or investment in human capital* specific skills to operate this equipment while a would-be acquirer needs to start from scratch and attaches a lower value to the equipment. Or there may be synergies with other productive assets that remain under the entrepreneur's possession.

(iii) Relatedly, *some assets are very hard to sell.* In particular, licensing trade secrets and know-how is quite difficult to the extent that the prospective licensee must know enough in order to be interested in securing a license, but may want to use the (legally unprotected) idea without paying once he has the information (Arrow 1962).

(iv) Alternatively, one may introduce *differential prospects of future credit rationing for the lenders and the borrower.* Suppose the lenders will not be credit rationed in the future while the borrower may be. The borrower, as we have seen, attributes a shadow value in excess of 1 to a unit of retained earnings while the lender does not. (This need not be the case. Lenders may themselves be exposed to credit rationing. See Chapter 13.) It may then be optimal not to confiscate all the borrower's assets in the case of failure even if the borrower is risk neutral.

(v) Contrary to what has been assumed, the borrower may be *risk averse.* Pledging her remaining resources (e.g., a house) in case of bankruptcy may inflict too large a cost on the borrower, given that bankruptcy may result from bad luck and not only from moral hazard.

(vi) The pledging of an asset may induce very *suboptimal maintenance* of the asset by the borrower, if maintenance cannot be carefully specified as part of the loan agreement. This moral-hazard problem is particularly acute when the borrower may receive signals that distress is imminent. Then, the probability that the asset will be transferred to the lenders is high, so that investment in maintenance is privately unprofitable for the borrower. Similarly, the entrepreneur may be unwilling to make follow-on investments into how better to utilize a piece of equipment if there is a nonnegligible probability that it will be reclaimed. It may then be desirable not to use the asset as collateral even if the value of the asset is identical for the borrower and for the lenders. For more on this, see Exercise 4.1.

17. Lacker (1991, 1992) finds conditions under which the optimal contract between a borrower and lenders is a collateralized debt contract, assuming, in particular, that the borrower values the collateral goods more highly than do the lenders.

18. See Jappelli et al. (2005) for Italian and cross-country evidence. For example, credit is harder to obtain in Italian provinces with long trials and large judicial backlogs.

(vii) Lastly, and a more subtle point, assets may come with an *attached managerial rent*, as noted by Holmström (1993). Suppose that the lenders cannot operate the assets themselves. They must then resort to a manager to operate the assets when they seize them. If these assets are again subject to moral hazard in the future, the manager brought in may need to be given a rent in order to behave (this rent is the analog of the term $p_H B/\Delta p$, but applied to future periods). By contrast, the entrepreneur need not concede this rent if she keeps the assets and operates them herself. We conclude that the lenders apply a discount, namely, the managerial rent, to the assets while the entrepreneur does not. (We will come back to this idea more formally in Chapter 14.)

4.3.4 Costly Collateral, Contingent Pledges, and the Strength of the Balance Sheet

Let us therefore posit the existence of a wedge in valuations of collateral, and assume the following:

- The borrower has no cash initially, so that the full investment I is defrayed by the lenders. The investment is used to purchase an asset.
- The asset is used in production, but still has a residual value after income is realized. This residual value is A for the entrepreneur and $A' \leqslant A$ for the lenders (so, there is a deadweight loss of $A - A'$ if the asset is seized).[19] Thus the collateral studied in this subsection is one (such as equipment acquired for, or intellectual property produced by, this project) that would not exist in the absence of funding and investment. By contrast, the next subsection will look at preexisting collateral (such as a family house).

A loan agreement specifies how income is shared in the case of success (as earlier), as well as possibly a contingent right for the lenders to seize the asset. More formally, let R_b and R_l denote the borrower's and the lenders' incomes in the case of success ($R_b + R_l = R$), and let y_S and y_F denote the probabilities that the borrower keeps the asset in the cases of success or failure.

Using the lenders' zero-profit condition and the assumption that the project can be financed only if the borrower is induced to behave, the borrower's utility (gross or net, since she has no cash on hand) is equal to the social surplus from undertaking the project, that is, the expected monetary profit (including the residual value of the asset in its most efficient use) minus the deadweight loss associated with the transfer of the asset to the lenders:

$$\begin{aligned} U_b &= p_H(R_b + y_S A) + (1 - p_H) y_F A \\ &= p_H R - I + A \\ &\qquad - [p_H(1 - y_S) + (1 - p_H)(1 - y_F)](A - A'). \end{aligned} \tag{4.8}$$

The optimal loan agreement maximizes U_b subject to the constraints that the borrower be willing to behave and that the lenders break even:

$$(\Delta p)[R_b + (y_S - y_F)A] \geqslant B \tag{IC$_b$}$$

and

$$p_H[R_l + (1 - y_S)A'] + (1 - p_H)(1 - y_F)A' \geqslant I. \tag{IR$_l$}$$

The incentive constraint (IC$_b$) says that the increase in the borrower's expected payoff (income plus increased probability of keeping the asset) associated with good behavior exceeds the private benefit of misbehaving. The "individual rationality" constraint (IR$_l$) requires that the lenders recoup their investment I on average.

As explained in Section 3.2.2, a good measure of the borrower's strength or creditworthiness is her level of pledgeable cash $p_H(R - B/\Delta p)$ compared with investment I. We can therefore measure the strength of the balance sheet in various ways: (minus) the investment level I, or the agency cost (private benefit B, inverse of the likelihood ratio $\Delta p/p_H$ for a given p_H). (Furthermore, if the borrower had some initial cash on hand $\tilde{A}$ that could contribute to defray the investment cost I (so the right-hand side of (IR$_l$) would become $I - \tilde{A}$), the borrower's balance-sheet strength would also increase with this level of cash $\tilde{A}$.) We now perform some comparative statics with respect to the strength of the balance sheet. As the strength of the balance sheet decreases, one observes successively three different regimes.[20]

19. Section 4.3.4 closely follows Holmström (1993).

20. The derivative of the Lagrangian with respect to y_S is positive if that with respect to R_b or that with respect to y_F is. Depending on the values of the parameters, some of the three regimes may not exist.

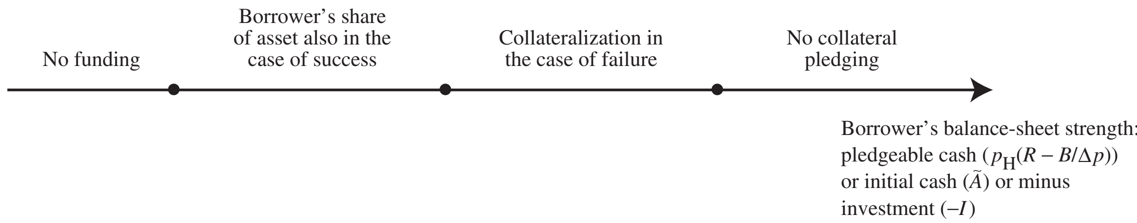

Figure 4.2 Only weak borrowers pledge collateral.

(i) *Strong balance sheet: no collateral:* $\{y_S = y_F = 1,\ R_b > 0\}$. The borrower always keeps the asset. Because the marginal rate of substitution between asset and money is higher for the borrower than for the lenders, it is optimal for the borrower to pledge money first. This no-collateral regime holds as long as the pledgeable income allows the lenders to recoup their investment, that is, as long as $p_H R - p_H B/\Delta p \geqslant I$.

(ii) *Intermediate balance sheet: collateral in the case of failure:* $\{y_S = 1,\ y_F \leqslant 1,\ R_b \geqslant 0\}$. If the asset is to be pledged, it is better to pledge it in the case of failure because this has attractive incentive properties.

(iii) *Weak balance sheet: borrower's share of asset in the case of success:* $\{y_S \leqslant 1,\ y_F = 0,\ R_b = 0\}$. The borrower's only compensation is a share of the asset (that is, here, some probability of keeping it) only in the case of success.

This theory predicts that *weak borrowers pledge more collateral than strong borrowers*, the intuition being that collateral pledging makes up for a lack of pledgeable cash. In other words, weak borrowers must borrow against assets and cash and not only against cash. The expression of the borrower's utility implies that the borrower prefers pledging as little collateral as possible. Therefore, the regime that prevails is the one that pledges the least collateral in expectation and yet is consistent with the incentive constraint (IC_b) and the breakeven constraint (IR_l). This implies that the prevailing regime is as depicted in Figure 4.2.

This testable implication of the moral-hazard model is to be contrasted with that of the adverse-selection model (see Section 6.3). There, we will show that when the borrower has private information about her firm's prospects at the date of contracting, only a strong borrower (namely, a borrower with a high probability of success) pledges collateral.

Lastly, it is important to stress the key role of *contingent pledging*. Transferring money to investors is by assumption more efficient than transferring assets, and so incentives are best provided by giving the entrepreneur a contingent share in the assets than a contingent share in income. The intuition for the results obtained above in this respect can be obtained by comparing the pledgeable incomes under noncontingent and contingent collateral pledges. That is, we simplify the analysis above by comparing only $\{y_S = y_F = 0\}$ with $\{y_S = 1, y_F = 0\}$.

Under a noncontingent collateralization of the assets, the pledgeable income is

$$p_H\left(R - \frac{B}{\Delta p}\right) + A'.$$

With a contingent collateralization, the incentive constraint is

$$(\Delta p)(R_b + A) \geqslant B,$$

and so, if $A < B/\Delta p$, say (assets do not suffice to provide incentives), the pledgeable income is

$$\begin{aligned} p_H\left[R - \left(\frac{B}{\Delta p} - A\right)\right] &+ (1 - p_H)A' \\ &= p_H\left(R - \frac{B}{\Delta p}\right) + A' + p_H(A - A'). \end{aligned}$$

A similar rationale will underlie the optimality of a contingent allocation of control rights (see Section 10.2.3).

Multiple assets. Suppose now that the investment I is used to purchase two equipments. These two assets have, say, the same residual values $A_1 = A_2$ to the borrower, and different residual values, $A_1' > A_2'$, say, to the lenders. That is, asset 1 is more redeployable than asset 2. We invite the reader to check, following the steps of the previous argument, that *the borrower pledges the more redeployable asset first.*

4.3.5 Pledging Existing Wealth

The previous subsection analyzed a discrete model of costly collateral pledging, in which collateral corresponded to the leftover value of the project's investment. This subsection develops a related framework, a variant of which will be used in Section 6.3. We assume here that the amount pledged is a continuous variable (this modification is inconsequential since the ability to "pledge stochastically" in the previous subsection de facto made the pledge a continuous variable). More interestingly, the collateral corresponds to the borrower's existing (non-project-related) wealth. For example, it could be the borrower's family house or shares in other ventures. The analysis and conclusions are strongly analogous to the previous ones, although the treatment of the borrower's participation constraint is different: the borrower, having no wealth of her own, was always willing to undertake the project in the previous subsection. This may not be so if she has to pledge her own wealth; the borrower would not want to simultaneously receive no reward for success and lose existing wealth through collateral pledges. Accordingly, region (iii) in Section 4.3.4 cannot exist.

Suppose that the entrepreneur can pledge an arbitrary amount C,

$$0 \leqslant C \leqslant C^{\max},$$

conditional on failing (we will later check that conditional collateral dominates unconditional collateral). Investors value collateral C at βC, where $\beta < 1$, when they seize it.[21]

The borrower's net utility, as usual, is equal to the NPV. The NPV is equal to its value in the absence of collateral, $p_{\mathrm{H}}R - I$, minus the deadweight loss associated with collateral pledging. This deadweight loss is equal to $(1-\beta)C$ times the probability, $1-p_{\mathrm{H}}$, that the firm fails. And so

$$U_{\mathrm{b}} = p_{\mathrm{H}}R - I - (1-p_{\mathrm{H}})(1-\beta)C.$$

The NPV is maximized when $C = 0$; the borrower will therefore not pledge collateral unless she needs to. Thus, if A denotes the borrower's cash on hand and $A \geqslant \bar{A}$, where

$$p_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right) = I - \bar{A},$$

then $C = 0$.

By contrast, firms with weaker balance sheets, i.e., $A < \bar{A}$, need to pledge collateral in order to raise funds.[22] Under collateral pledging, the incentive constraint becomes[23]

$$(\Delta p)(R_{\mathrm{b}} + C) \geqslant B,$$

since the borrower loses both her reward R_{b} and the collateral when she fails (her stake is just larger).

The investors' breakeven condition becomes

$$p_{\mathrm{H}}(R - R_{\mathrm{b}}) + (1-p_{\mathrm{H}})\beta C \geqslant I - A,$$

or, using the incentive compatibility constraint,

$$p_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right) + p_{\mathrm{H}}C + (1-p_{\mathrm{H}})\beta C \geqslant I - A.$$

Note that the pledging of collateral raises pledgeable income both directly (term $(1-p_{\mathrm{H}})\beta C$) and indirectly through the reduction in entrepreneurial reward (term $p_{\mathrm{H}}C$).[24] To minimize the deadweight loss, the borrower pledges the minimum amount of collateral that allows investors to break even:

$$C(A) = \frac{(I-A) - p_{\mathrm{H}}(R - B/\Delta p)}{p_{\mathrm{H}} + (1-p_{\mathrm{H}})\beta}.$$

Note that $C(A)$ is a decreasing function of A: among firms that pledge collateral, those with the weakest balance sheet pledge more collateral.

Finally, we claimed that conditional pledges dominate unconditional ones. Suppose that the borrower pledges C regardless of the final outcome. Then the deadweight loss is higher for a given amount of collateral and the NPV becomes

$$\hat{U}_{\mathrm{b}} = p_{\mathrm{H}}R - I - (1-\beta)C.$$

21. The dichotomous example of Section 4.3.4 corresponds to $C = (1-y_{\mathrm{F}})A$ and $\beta = A'/A$.

22. We assume that $C^{\max}$ is small enough that the NPV remains positive even if the borrower pledges all assets:

$$p_{\mathrm{H}}R - I - (1-p_{\mathrm{H}})(1-\beta)C^{\max} \geqslant 0.$$

23. A different way of writing this constraint is

$$p_{\mathrm{H}}R_{\mathrm{b}} + (1-p_{\mathrm{H}})(-C) \geqslant p_{\mathrm{L}}R_{\mathrm{b}} + (1-p_{\mathrm{L}})(-C) + B.$$

24. This latter term (and the validity of the analysis) rests on the condition that $R_{\mathrm{b}} \geqslant 0$, which we will assume (this is guaranteed by imposing $B/\Delta p \geqslant C^{\max}$). For large amounts of collateral, it is no longer possible to substitute collateral for reward, since the latter would become negative and violate limited liability.

The incentive compatibility constraint is

$$(\Delta p)R_{\mathrm{b}} \geqslant B,$$

and the investors' breakeven condition is

$$p_{\mathrm{H}}(R - R_{\mathrm{b}}) + \beta C \geqslant I - A.$$

When $A < \bar{A}$, the amount of collateral is

$$\hat{C}(A) = \frac{(I - A) - p_{\mathrm{H}}(R - B/\Delta p)}{\beta} = \frac{p_{\mathrm{H}} + (1 - p_{\mathrm{H}})\beta}{\beta} C(A) > C(A).$$

Intuitively, cash is more cheaply transferred than assets. Thus, not only is the deadweight loss higher for a given amount of collateral, but there is also a need for a larger collateral. And so the conditional pledge dominates the unconditional one.[25]

Remark (loan size and collateral requirement). This analysis presumes a single "margin" for concessions, namely, costly collateral pledging. Adding other margins yields interesting covariations. For example, Exercise 4.17 looks at a variable investment size. As the agency cost decreases (B, or, keeping p_{H} constant, $p_{\mathrm{H}}/\Delta p$ decreases), the firm expands and borrows more (the investment size I increases) and pledges less collateral.[26] Interestingly, Boot et al. (1991) find empirically that larger loans have lower collateral requirements.

More generally, it would be interesting to let collateral be codetermined with other corporate finance patterns. Another finding of Boot et al. (1991) is that loans of longer maturities have less collateral. As the next chapter will show, the optimal maturity of liabilities is longer for firms with stronger balance sheets. Because such firms can also afford pledging less collateral, this other finding of Boot et al. also makes a lot of sense.

4.3.6 Executive Turnover as Costly Collateral Pledging

At a broad level of abstraction, the asset that is being pledged by the entrepreneur in the case of poor performance need not be a physical asset. The pledge could refer to any transfer or action that brings a benefit to investors and a larger cost to the entrepreneur. In particular, the entrepreneur may post her job as collateral, either directly as a commitment to quit in the case of poor performance, or, more plausibly, indirectly through institutional changes that make it easier for investors to dismiss the manager: an increase in the number of outsiders on the board, removal of takeover defenses, termination rights granted to the venture capitalist, and so forth.

Investors benefit from the ability to remove the manager because they may find another manager with a higher productivity or lower private benefits. Executive turnover, however, may involve a deadweight loss as discussed above: the new manager will enjoy a rent, which will be received neither by the entrepreneur nor by the investors. Hence, the cost to the incumbent entrepreneur of being removed may well exceed the benefit to the investors.

What does this analogy[27] imply for the executive turnover pattern? First, turnover should be more likely following poor performance, in the same way collateral is more likely to go to investors following poor performance; this is indeed the case in practice (see Section 1.2.3). Second, turnover is negatively correlated with explicit incentives, in the same way as the entrepreneur receives nothing when collateral is seized. This prediction of a positive covariation between explicit and implicit incentives is also supported by empirical evidence.

4.4 The Liquidity–Accountability Tradeoff

We have assumed that the entrepreneur's compensation is delayed until the consequences of her management (the final profit) are realized. As is intuitive and will be confirmed in the analysis below, it was indeed optimal to proceed in this way in the environment that has been analyzed until now: the more delayed the compensation, the larger the volume of information available, and thus the more precise the assessment of the entrepreneur's performance. In reality, entrepreneurial compensation accrues progressively and not only at the "end." For one thing,

25. As noted in the previous footnote, this assumes that the levels of collateral are small enough that with conditional pledging R_{b} remains positive.

26. As A increases, the firm expands and pledges less collateral, but it is harder to get any prediction on net borrowing $I - A$.

27. The formal treatment of the analogy requires adding a second period (as in Section 4.7 below, but without a second-period investment) and is left to the reader.

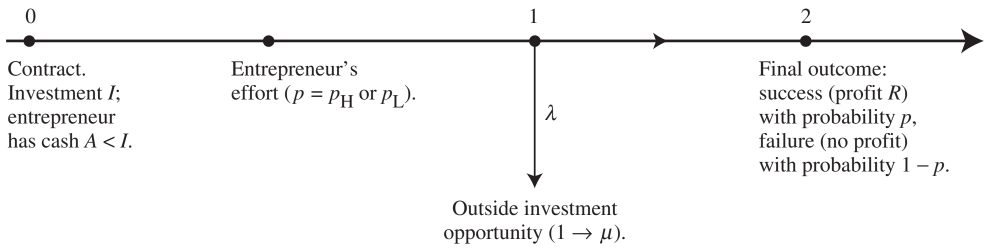

Figure 4.3

the entrepreneur needs to consume along the way, and would therefore like to spread her compensation over time. This section investigates a related reason, namely, that the entrepreneur may want to cash out in order to undertake new and profitable activities.

Letting the entrepreneur cash out before her performance is clearly ascertained aggravates moral hazard. There is in general a tradeoff between liquidity and accountability. The problem of dealing with the imperfection in performance measurement at the entrepreneur's exit date is compounded when the investors cannot verify whether the entrepreneur indeed faces attractive outside investment opportunities. This lack of observability creates scope for "strategic exit." The option of exiting early further aggravates the moral-hazard problem because an early exit allows the entrepreneur to escape the sanction attached to a poor performance.

The theme of this section is an old one in corporate finance and corporate law. As Coffee (1991) notes, "American law has said clearly and consistently since at least the 1920s that those who exercise control should not enjoy liquidity and vice versa." In the policy debate, the existence of a tradeoff between liquidity and accountability has been a focal object of debate primarily at the level of active monitors. In a nutshell (we will come back to this theme in Chapter 9), it has often been argued that the institutional investors in the United States enjoy much more liquidity than their Japanese and European counterparts and therefore are much less prone to monitoring ("exercise voice"). Note, though, that they have easier access to information and to judicial action against corporate insiders, which lowers the cost of limited monitoring relative to their European and Japanese counterparts.

To unveil some implications of the liquidity–accountability tradeoff and its limits, let us generalize the fixed-investment model of Section 3.2 to allow for the possibility that the entrepreneur enjoys an attractive new investment opportunity at an intermediate date, which is after the project has been financed and the investment sunk but before the outcome is realized.[28] This new investment opportunity is fleeting; in particular, it disappears if it is not taken advantage of when the profit on the initial project accrues. The timing is described in Figure 4.3.

As usual, we assume that the entrepreneur's cash A is insufficient to finance the initial investment I. There is moral hazard: the entrepreneur enjoys no private benefit if she behaves (in which case the probability of success is p_H) and private benefit $B > 0$ if she misbehaves (the probability of success is then p_L). The project yields R if successful and 0 if it fails. This final outcome (R or 0) is obtained *whether or not the entrepreneur takes advantage of the new investment opportunity*. Investors and the entrepreneur are risk neutral, and the latter is protected by limited liability. We assume that the investment would be financed in the absence of new reinvestment opportunities:

$$p_H\left(R - \frac{B}{\Delta p}\right) \geqslant I - A.$$

The new feature is the possible existence of an outside investment opportunity for the entrepreneur. We will say that the entrepreneur faces a "liquidity shock" if such an opportunity arises. The rationale for this terminology is that the model

28. The model is a simplified version of the one in Aghion et al. (2004), to which we refer for more detail. There is also a large literature on the liquidity–control tradeoff for active monitors (see Section 9.4).

admits alternative interpretations in which the entrepreneur needs money at the intermediate stage for reasons other than new investment opportunities. More generally, the marginal value of the entrepreneur of having cash available at the intermediate date is high. It might be that the entrepreneur is ill, or wants to send her children to college, or to acquire a property.

When a new investment opportunity arises, which happens with probability λ, the entrepreneur (who, it can be shown, has optimally invested all her wealth A in the initial investment) can only rely on the amount r_b that she can contractually withdraw at the intermediate date to reinvest in the new venture. We assume that the entrepreneur receives μr_b when investing r_b, where $\mu > 1$. None of this return is pledgeable to the investors.[29]

Consider the following class of contracts. The entrepreneur receives

- r_b at the intermediate date, and nothing at the final date, in the case of a liquidity shock;
- R_b in the case of success (and 0 in the case of failure) when the final outcome is realized and nothing at the intermediate stage, in the absence of a liquidity shock.

This "menu" deserves several comments. First, the type of compensation is contingent on the presence or absence of a liquidity shock. This raises no problem when the existence of a liquidity shock is verifiable by the investors. As we already observed, though, this need not be the case, and it must then be the case that the entrepreneur indeed finds it privately optimal to choose *full exit* (take r_b) when facing a liquidity shock and *full vesting* (wait and receive R_b in the case of success) in the absence of a liquidity shock.

Second, one may wonder whether this full exit/full vesting menu is not too restrictive, in that one could find better schemes. In particular, one might in the case of a liquidity shock allow for "*partial vesting*" (the entrepreneur receives some performance-contingent delayed compensation together with some cash r_b at the intermediate date with an option to convert this cash into additional shares). It turns out that under risk neutrality, partial vesting, and actually arbitrary, schemes do not improve on the limited class considered above in case (a) below, and may not improve in case (b); and that in the case of possible improvement in (b) it suffices to consider partial vesting schemes. We will solve for the optimal mechanism and will point it out if the latter involves partial vesting.

Third, the reader may wonder where the amount r_b comes from, given that the firm generates no cash at the intermediate date, of which the entrepreneur could keep some fraction. This is a matter of implementation. When computing the optimal state-contingent allocation, one need only know that r_b will have to be paid *in some way* by the investors and therefore must be subtracted from pledgeable income. Only thereafter comes the question of implementation. One possibility, although not the most realistic one in our context, is that the investors initially bring more than $I - A$: liquidity, in the form of Treasury bonds, say, is hoarded so as to be able to honor the contract with the entrepreneur in the case of exit. Alternatively, and as will later be emphasized, securities can be issued at the intermediate date (that pay off in the case of eventual success). This dilution of initial claimholders allows the firm to raise sufficient cash to compensate the entrepreneur at the exit date.

(a) *Verifiable liquidity shock.* Let us begin with the benchmark case in which the liquidity shock is observable by the investors. There is then a single dimension of moral hazard: the entrepreneur must be induced to behave. Intuitively, all incentives are provided by the contingent compensation that the entrepreneur receives when she does not exit. This intuition is confirmed by the analysis of the incentive compatibility constraint:

$$\lambda\mu r_b + (1-\lambda)p_H R_b \geqslant \lambda\mu r_b + (1-\lambda)p_L R_b + B. \quad (\mathrm{IC_b})$$

That is, with probability λ, the entrepreneur cashes out and reinvests, obtaining μr_b. Because r_b cannot be made contingent on profit, it has no impact on the entrepreneur's effort decision. All incentives are provided by the share R_b held in delayed compensation in the absence of a liquidity shock. Indeed, the incentive compatibility constraint can be rewritten as

$$(1-\lambda)(\Delta p)R_b \geqslant B.$$

29. See Exercise 4.5 for the extension to partly pledgeable return.

This is but the incentive constraint obtained in Section 3.2 in the absence of a liquidity shock ($\lambda = 0$) except that the entrepreneur's stake R_b must be magnified since the incentive sanction will bite only with probability $1 - \lambda$.

The pledgeable income is the maximal expected income that can be pledged to the investors without destroying incentives. *For a given* r_b, this pledgeable income is equal to the firm's expected income, $p_H R$, minus the minimum expected compensation that must be given to the entrepreneur to preserve incentives:

$$p_H R - \Big\{\lambda r_b + (1-\lambda) p_H \min_{\{R_b \text{ satisfying (IC}_b)\}} R_b\Big\} = p_H\left(R - \frac{B}{\Delta p}\right) - \lambda r_b.$$

Thus, everything is as if the entrepreneur contributed not A but $[A - \lambda r_b]$, since she gets a fixed amount r_b with probability λ.

The social surplus (NPV), which, because of the competitiveness of the financial market, goes to the entrepreneur, is

$$U_b = \text{NPV} = p_H R - I + \lambda(\mu - 1) r_b. \qquad (4.9)$$

Thus more liquidity (a higher r_b) increases the borrower's net utility U_b. Of course, the catch is that more liquidity reduces the pledgeable income. So, in the optimal contract, r_b will be set at the highest possible level consistent with having enough pledgeable income to fund the investment:

$$r_b = r_b^*,$$

where

$$p_H\left(R - \frac{B}{\Delta p}\right) - \lambda r_b^* = I - A;$$

for, it is optimal to set

$$R_b^* = \frac{B}{(1-\lambda)\Delta p}$$

so as to maximize the liquidity of the entrepreneur's claim. Intuitively, the entrepreneur values income more early than late and so it is optimal to minimize delayed compensation once incentives are sufficient.[30]

30. To prove this more formally, maximize U_b subject to (IC_b) and the financing constraint:

$$p_H(R - R_b) - \lambda r_b \geqslant I - A.$$

Note also that r_b^* increases with A. And so an entrepreneur with a stronger balance sheet enjoys more liquidity.

(b) *Nonverifiable liquidity shock and strategic exit.* When at date 1 only the entrepreneur knows whether she faces a liquidity shock, moral hazard becomes multidimensional. The entrepreneur now has the option to "misrepresent" the existence or nonexistence of a liquidity shock. Furthermore, the two forms of moral hazard interact. The entrepreneur, if she decides to misbehave, may well want to strategically exit before the consequences of her behavior are discovered. The investors' inability to verify the existence of a liquidity shock thus aggravates the incentive problem. The agency cost is accordingly raised.

To simplify the exposition, we will assume in the rest of the section that

$$p_L = 0.$$

This assumption implies that, were the entrepreneur to misbehave, the entrepreneur would indeed want to cash out early even when she has no new investment opportunity: the delayed claim, $p_L R_b$, would then be valueless. More generally, a small probability of success in the case of misbehavior induces strategic exit. And so the entrepreneur's payoff in the case of misbehavior becomes

$$[\lambda\mu + 1 - \lambda] r_b + B$$

(the multiplier μ applies only in the case of a liquidity shock). The incentive constraint is now

$$\lambda\mu r_b + (1-\lambda) p_H R_b \geqslant [\lambda\mu + 1 - \lambda] r_b + B \qquad (\text{IC}_b)$$

or

$$(1-\lambda)[p_H R_b - r_b] \geqslant B. \qquad (\text{IC}_b')$$

Because $p_L = 0$, one verifies that the nonverifiability of the liquidity shock aggravates moral hazard, as this constraint can be rewritten as

$$(1-\lambda)[(\Delta p) R_b - r_b] \geqslant B. \qquad (\text{IC}_b'')$$

In a sense, the entrepreneur can avail herself of r_b even in the absence of a liquidity shock, and the performance-contingent compensation must accordingly be higher powered.

Does the entrepreneur have an incentive to select correctly in the menu when she behaves? The incentive constraint (IC_b') relative to the effort choice implies that $p_\mathrm{H}R_\mathrm{b} > r_\mathrm{b}$, and so the entrepreneur strictly prefers the delayed compensation when facing no liquidity shock. In contrast, we will need to investigate whether the entrepreneur has an incentive to cash out in the case of a liquidity shock, that is, whether

$$\mu r_\mathrm{b} \geqslant p_\mathrm{H}R_\mathrm{b}. \tag{4.10}$$

Let us ignore this constraint for the moment.

The NPV *for a given* r_b is unchanged by the possibility of strategic exit. It is

$$U_\mathrm{b} = p_\mathrm{H}R - I + \lambda(\mu - 1)r_\mathrm{b}.$$

In contrast, the agency cost has increased; that is, the pledgeable income is now reduced to

$$\begin{aligned} p_\mathrm{H}R - \Big\{\lambda r_\mathrm{b} + (1-\lambda)p_\mathrm{H} \min_{\{R_\mathrm{b} \text{ satisfying } (\mathrm{IC}_\mathrm{b})\}} R_\mathrm{b}\Big\} &= p_\mathrm{H}\left(R - \frac{B}{\Delta p}\right) - r_\mathrm{b} \\ &< p_\mathrm{H}\left(R - \frac{B}{\Delta p}\right) - \lambda r_\mathrm{b} \end{aligned}$$

when $r_\mathrm{b} > 0$.

Again it is optimal to provide the entrepreneur with as much liquidity as is consistent with the financing constraint. So

$$r_\mathrm{b} = r_\mathrm{b}^{**} < r_\mathrm{b}^{*},$$

with

$$p_\mathrm{H}\left(R - \frac{B}{\Delta p}\right) - r_\mathrm{b}^{**} = I - A.$$

Delayed compensation is then given by (IC_b') taken with equality

$$R_\mathrm{b} = R_\mathrm{b}^{**} = \frac{B + (1-\lambda)r_\mathrm{b}^{**}}{(1-\lambda)\Delta p} > R_\mathrm{b}^{*}.$$

The possibility of strategic exit hurts the entrepreneur since from (IC_b') we see that she will be allowed to enjoy less liquidity than she would otherwise. Her stake in the firm is made less liquid in order to prevent her from shirking and exiting.

Lastly, we must return to the neglected constraint (4.10). If

$$\mu r_\mathrm{b}^{**} \geqslant p_\mathrm{H}R_\mathrm{b}^{**},$$

then the ignored constraint (4.10) is indeed satisfied. The optimal scheme is then our menu of a full exit option (r_b^{**}) and a fully vested option (R_b^{**} in the case of success). If instead the constraint is not satisfied, as is the case when the firm has a weak balance sheet (A is low), then the liquid claim is too small to make full exit attractive enough even in the case of a liquidity shock.[31] It is easy to show that the *structure* of the incentive scheme must be changed slightly and that the entrepreneur's claim involves *partial vesting*:

- the entrepreneur receives some "baseline," illiquid share R_b^0 in the case of success (with value $p_\mathrm{H}R_\mathrm{b}^0$);
- the entrepreneur further receives cash r_b^{**} at the intermediate date, which she has the option to convert into extra shares paying ΔR_b in the case of success, with total stake $R_\mathrm{b} \equiv R_\mathrm{b}^0 + \Delta R_\mathrm{b}$ if she elects this conversion option.

The entrepreneur's utility ($p_\mathrm{H}R - I + \lambda(\mu-1)r_\mathrm{b}^{**}$) is unchanged. Only the composition of the compensation package is altered.[32]

To sum up, the (quite plausible) unobservability of the liquidity shock makes it harder for the entrepreneur to receive a liquid claim. It implies more *vesting* (a more delayed payoff for the entrepreneur).

In practice, contracts often have clauses for accelerating vesting—the entrepreneur can cash faster—in certain contingencies. These contingencies may either be direct performance measures (income,

31. The ignored constraint can be rewritten as

$$(\mu - 1)r_\mathrm{b}^{**} \geqslant \frac{B}{(1-\lambda)}.$$

32. To show this, note that the added constraint cannot increase the value of the program. So we just need to show that one can do as well as when one ignores the constraint. The incentive constraint relative to the effort choice under the partial vesting scheme is

$$\lambda[\mu r_\mathrm{b}^{**} + p_\mathrm{H}R_\mathrm{b}^0] + (1-\lambda)p_\mathrm{H}R_\mathrm{b} \geqslant [\lambda\mu + 1 - \lambda]r_\mathrm{b}^{**} + B.$$

The pledgeable income is, using this constraint satisfied with equality,

$$\begin{aligned} p_\mathrm{H}R - \left[\lambda(r_\mathrm{b}^{**} + p_\mathrm{H}R_\mathrm{b}^0) + (1-\lambda)\left(r_\mathrm{b}^{**} + \frac{B - \lambda p_\mathrm{H}R_\mathrm{b}^0}{1-\lambda}\right)\right] \\ = p_\mathrm{H}\left(R - \frac{B}{\Delta p}\right) - r_\mathrm{b}^{**}. \end{aligned}$$

Thus, the pledgeable income depends only on r_b^{**}. The entrepreneur must find it privately optimal to convert the cash into shares when there is no liquidity shock and to exit when there is one:

$$\mu r_\mathrm{b}^{**} \geqslant p_\mathrm{H}(\Delta R_\mathrm{b}) \geqslant r_\mathrm{b}^{**}.$$

Thus it suffices to choose ΔR_b in the interval defined by these two inequalities (which is consistent with $\Delta R_\mathrm{b} \leqslant R_\mathrm{b}$ since we are in the case $\mu r_\mathrm{b}^{**} < p_\mathrm{H}R_\mathrm{b}^{**}$ by assumption). Because ΔR_b has no impact on the NPV and the pledgeable income, we have shown that this simple change in the structure of compensation allows us to satisfy the *ex post* revelation constraints at no cost.

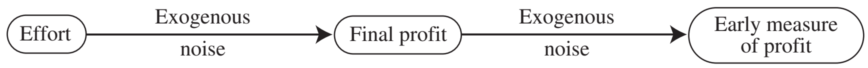

Figure 4.4

patents, etc.) or result from market monitoring. We now turn to the latter possibility.

(c) *Facilitating exit through speculative monitoring and the reverse pecking order.* As we have seen, the cost of liquidity is that it makes the entrepreneur less accountable since she can "get away with a poor performance." Ideally, one would want to have an early assessment or "picture" of the entrepreneur's performance and thereby be able to measure it before the profit actually accrues. Chapter 9 will emphasize the key role played by financial markets in the measurement of the value of assets in place. The buyers of claims in the firm are incentivized to assess their value; the price fetched by the securities in a public offering, for example, conveys useful information about the likely performance of the firm.

Chapter 9 will stress the use of market monitoring as a way to filter out at any point in time some of the future exogenous noise that garbles the assessment of performance. Here we want to abstract completely from this consideration and assume rather that an early signal is available that is a noisy version of final performance. That is, the final profit is a superior way of assessing the entrepreneur's performance. In technical terms, the profit is a "sufficient statistic" or "summary" for the pair of observables (profit, signal) when trying to infer effort.[33] Crudely speaking, there is nothing to be learned from the signal when one already knows the profit (see Figure 4.4 for a schematic).

The fact that the signal is a garbled version of the final profit implies that, in the absence of a liquidity shock ($\lambda = 0$), the signal should just be ignored, and the compensation entirely based on the best measure of performance, namely, profit.

We will later interpret this signal as the price fetched in an initial public offering (IPO) or other security issue; just assume for the moment that it comes "out of the blue" at the intermediate date, just after the entrepreneur learns whether she faces a liquidity shock and before she cashes out.

The signal can be "good" or "bad." Let

$$q_{\mathrm{H}} \equiv \Pr(\text{good signal} \mid \text{high effort})$$

and

$$q_{\mathrm{L}} \equiv \Pr(\text{good signal} \mid \text{low effort}).$$

Assume[34]

$$q_{\mathrm{H}} > q_{\mathrm{L}}.$$

Intuitively, and because of risk neutrality, if the entrepreneur announces that she wants to cash out (case (b)), one should (i) use the signal and (ii) give her cash $\hat{r}_{\mathrm{b}}$ only if the signal is good. For example, in the case in which the liquidity shock is not verifiable (case (b)), the incentive constraint relative to effort can now be written:

$$\lambda q_{\mathrm{H}} \mu \hat{r}_{\mathrm{b}} + (1-\lambda) p_{\mathrm{H}} R_{\mathrm{b}} \geqslant q_{\mathrm{L}}[\lambda\mu + (1-\lambda)]\hat{r}_{\mathrm{b}} + B. \tag{IC$_\mathrm{b}$}$$

Making the size of the liquid claim contingent on the signal ($\hat{r}_{\mathrm{b}}$ if the signal is good, 0 if it is bad) relaxes the constraint. Let

$$r_{\mathrm{b}} \equiv q_{\mathrm{H}} \hat{r}_{\mathrm{b}} \quad \text{and} \quad \theta \equiv \frac{q_{\mathrm{L}}}{q_{\mathrm{H}}} < 1.$$

The incentive constraint can be rewritten as

$$\lambda\mu r_{\mathrm{b}} + (1-\lambda) p_{\mathrm{H}} R_{\mathrm{b}} \geqslant [\lambda\mu + (1-\lambda)]\theta r_{\mathrm{b}} + B.$$

While the entrepreneur's expected utility for a given r_{b} is unchanged, the pledgeable income increases to

$$p_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right) - r_{\mathrm{b}}[1 - (1-\theta)(\lambda\mu + 1 - \lambda)],$$

and so r_{b} and the NPV are increased. In that sense, liquidity is enhanced by the existence of speculative monitoring.

Application. These ideas can be illustrated in the context of venture capital, for example. One difference with the model analyzed above is that at

33. For the concept of sufficient statistic, see Section 3.2.4.

34. Let x and y denote the probability of a good signal when the profit is R and 0, respectively, with (this is the definition of a "good signal") $x > y$. Then

$$q_{\mathrm{H}} = p_{\mathrm{H}} x + (1-p_{\mathrm{H}}) y > q_{\mathrm{L}} = p_{\mathrm{L}} x + (1-p_{\mathrm{L}}) y.$$

least two parties with control over the venture—the entrepreneur and the venture capitalist (the active monitor)—may each want to exit. But the broad principles stated above apply. Venture capital agreements carefully plan the conditions for their exit. For example, venture capitalists usually exit four to five years after the initial capital injection. At this time, the performance is usually still unknown (for example, it may take ten or fifteen years for a drug to go through the research and development stages, to be tested, to obtain regulatory approval, and to finally enter the market). So it is particularly important to obtain some advanced, even noisy, estimate of future profits. This "photographing" of the value of assets in place is in part synchronized with the exit mechanism. The conversion of the venture capitalist's convertible preferred stocks into common stocks is usually contingent on the value achieved at the IPO.[35]

Recall that at the beginning of the section we provided several interpretations for the way the transfer r_b is implemented. The first was the hoarding of liquidity, say, in the form of Treasury bonds, to allow the entrepreneur to cash out. This method, however, has the substantial drawback of not generating any information about the value of assets in place.

Similarly, issuing safe debt (which would be feasible if the profit in the case of failure were strictly positive) would not convey any information about the probability of success, and therefore would keep the agency cost high.

In practice, therefore, the exit mechanism is associated with the issuance of *risky securities* (say equity claims). The observation of the signal by new claimholders, however, is costly, so that incentives must be given for the production of this interim information. The riskier the claim, the more incentive the buyers of the claim have to carefully assess the value of assets in place. In the case of venture capital, the exit mechanism is indeed linked to either an IPO or a sale to a large buyer, in any case with the sale of equity.

35. The venture capitalist's reward and timing of exit depends on other parameters besides the start-up's own performance. As discussed in Section 2.5, IPOs also "time the market." For example, after the 2000 collapse of the Internet bubble, the market for IPOs dried up; venture capitalists were deprived of an exit option and could not reinvest in new start-ups.

The need for a precise assessment at the date of exit calls for a reversal of the "pecking-order hypothesis." This hypothesis, whose rationale we will investigate in Chapter 6, holds that, when issuing claims outside, firms prefer to start with relatively riskless claims and issue very risky ones only as a last resort. So they will first issue safe debt, then risky debt, then preferred stocks, and finally equity. The need to incentivize the measurement of the value of assets in place instead suggests issuing risky securities first.

4.5 Restraining the Ability to Borrow: Inalienability of Human Capital

We have until now assumed that the loan agreement between the entrepreneur and the lenders is not renegotiated. Since the agreement is Pareto-optimal, renegotiation cannot strictly improve the welfare of both sides to the agreement. Hart and Moore (1994) have argued that renegotiation may nevertheless occur if the entrepreneur is indispensable for the completion of the project. Hart and Moore's idea is that the entrepreneur can blackmail the lenders and try to obtain a bigger share of the pie by threatening not to complete the project.[36]

To illustrate in the simplest fashion how this blackmail might operate, suppose there is no moral hazard, so $B = 0$, and that the entrepreneur has no cash, so $A = 0$. Since

$$p_H R > I,$$

the (positive-NPV) project is then financed in the absence of contract renegotiation. The entrepreneur can, for example, write a debt contract specifying that D will be paid to the lenders in the case of success, where

$$p_H D = I.$$

Introducing renegotiation, Hart and Moore consider a timing similar to that in Figure 4.5.[37] The project

36. We here focus on holdups by *borrowers*. See Section 9.4 for the opposite problem of holdups by *lenders*, which refers to the relationship banker "expropriating" the entrepreneur's future surplus thanks to his superior knowledge of the firm relative to other potential lenders. Expropriation of the entrepreneur's specific investment through high interest rates is the dark side of "relationship banking." In this case, it is the investors who need to compete in order to enhance the borrower's bargaining power.

37. More precisely, Hart and Moore build a multiperiod model, in which the timing for each period is similar to that of Figure 4.5. The scope of their analysis is accordingly much broader than the account given in this section.

Figure 4.5

yields nothing if it is not completed. And, because of the absence of moral hazard, it yields R with probability p_{H} and 0 with probability $1 - p_{\mathrm{H}}$ if it is completed.

There are two key assumptions for the analysis. First, the lenders cannot bring in a new entrepreneur to complete the project if the entrepreneur refuses to complete it; one may have in mind that part of the investment I is devoted to the acquisition of knowledge by the entrepreneur and that this knowledge is indispensable to complete the project. More generally, bringing in a new entrepreneur could substantially delay the project and/or wastefully duplicate the investment in human capital (besides, the new entrepreneur might herself blackmail the lenders if the first one is no longer available to complete the project). Note that, in contrast with physical assets, the investment in the entrepreneur's human capital cannot be seized: it is inalienable.

The second assumption is that the action of "completing the project" can be contracted upon after, but not before, the investment is incurred. Therefore, in effect, the renegotiation itself replaces effort as the source of moral hazard.

The key ingredient of the analysis is the description of the renegotiation process. Two opposite views can be held on this matter. On the one hand, one may predict that the lenders will stay put and will refuse to renegotiate. If the project has a deadline, a self-interested entrepreneur will complete the project even in the absence of renegotiation, since completing the project brings her

$$p_{\mathrm{H}}(R - D) = p_{\mathrm{H}}R - I > 0.$$

On the other hand, one may, following Hart and Moore, take a more optimistic view of the entrepreneur's bargaining power and argue that in this situation both sides have bargaining power, as both receive 0 in the case of noncompletion.[38] Let us assume that the lenders (respectively, entrepreneur) receive a fraction θ (respectively, $1 - \theta$) of the pie in the renegotiation. The fraction θ reflects the lenders' bargaining power. Anticipating renegotiation, the lenders are willing to invest in the firm if and only if

$$\theta(p_{\mathrm{H}}R) \geqslant I.$$

Note that θ cannot exceed D/R. Otherwise, the entrepreneur would just refrain from renegotiating and complete the project, leaving only D to the lenders in the case of success.

The interesting case is when θ is smaller than D/R. Then

$$\theta(p_{\mathrm{H}}R) < I,$$

and the project is not financed: although the lenders break even in the absence of renegotiation, renegotiation reduces their share in the case of success and transforms lending into a money-losing operation. The firm then suffers from credit rationing—the nonfinancing of a positive-NPV project—despite the "absence" of moral hazard.[39] This model can be viewed as one of *expropriation of the lenders' investment.*[40]

Determinants of bargaining power. We now identify some factors that reduce the borrower's bargaining power (increase θ) and thus help her obtain funding.

38. Arguably, this view may be more relevant if, for example, there is no deadline and the value, initially $p_{\mathrm{H}}R$, shrinks over time due to discounting. Then the lenders can less easily stay put and make the entrepreneur responsible for destroying the value of the project.

39. Actually, the model is formally identical to one with moral hazard. It suffices to define an "equivalent private benefit" B:

$$\theta p_{\mathrm{H}}R \equiv p_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right).$$

The model with renegotiation (with parameter θ) and no moral hazard is equivalent to the model without renegotiation and with moral hazard (with private benefit B).

40. It thereby bears some resemblance to the models of expropriation of specific investment in the industrial organization and labor economics literatures (Grout 1984; Klein et al. 1978; Williamson 1975, 1985). It is also very similar to the model in Jappelli et al. (2005), where *ex post* the lender can refuse to pay unless brought to court, but the inefficiency of the court implies that the lenders can secure only a fraction of the final value of the assets.

One such factor is *reputation*. Reputation may operate on the *borrower*'s side. That is, the borrower may in the past have developed a reputation for not opportunistically renegotiating her loans. We refer the reader to Section 3.2.4 for a discussion of reputational capital. The *lenders* may also develop a reputation for not accepting to renegotiate. For example, a bank may lend to several such borrowers and may credibly adopt a tough stance with all of them knowing that, were it to give in to one of them, it would be in a weak bargaining position with the others.[41]

Relatedly, if completion cannot be described in a formal contract even after investment has occurred, the lenders may be worried that by forgiving some debt they would expose themselves to *further blackmail* by the entrepreneur (as do families and the police when they pay a ransom to a kidnapper). They may then want to resist the entrepreneur's blackmail in order not to appear weak.

The second factor that may affect θ is the *dispersion of lenders*. We have already mentioned the possibility that dispersion may hinder renegotiation when we discussed debt overhang. We will come back to this theme when defining the notion of a soft budget constraint in Chapter 5.

A third factor affecting the parties' bargaining power is their *outside options*.[42] We assumed above that they had none: the borrower had no substitute activity and the lenders could not replace the entrepreneur by someone else. Let us conclude this discussion by introducing outside options, starting with the entrepreneur. Suppose that the entrepreneur can obtain utility V in an alternative project (none of which can be seized by the investors), where

$$(1-\theta)p_{\mathrm{H}}R < V < p_{\mathrm{H}}R.$$

These inequalities imply two things. First, it is inefficient for the entrepreneur to abandon the project ($V < p_{\mathrm{H}}R$). Second, by exercising her outside option, the entrepreneur obtains more (V) than what he would get if this outside option were not available ($(1-\theta)p_{\mathrm{H}}R$). Put differently, to "estimate" the entrepreneur's bargaining power in renegotiation, one must look at her outside option. The investors must then lower their stake to θ' to "keep the entrepreneur on board," where

$$V = (1-\theta')p_{\mathrm{H}}R.$$

That is, the entrepreneur's outside option amounts to a redefinition of the investors' bargaining power from θ to $\theta' < \theta$. The entrepreneur's outside option here never benefits her and may hurt her, as the investors may no longer be willing to finance her project.[43]

Lastly, the entrepreneur's bargaining power is weaker when she can be replaced, possibly at a cost, by another entrepreneur to complete the project. This theme is familiar from industrial organization: a party's (here, the investors') specific investment is better protected if this party can use *ex post competition* to secure a better bargaining position.[44] In the context of our financing model, suppose that the entrepreneur is not completely indispensable; that is, the investors can, by incurring cost $c < p_{\mathrm{H}}R$, find a replacement for the entrepreneur. For example, c may stand for the cost incurred by a new entrepreneur (and compensated for by the lenders) to obtain the knowledge necessary to complete the project.

The loan agreement can specify that the lenders can seize the assets and fire the entrepreneur. In this case, the lenders will not settle for less than $p_{\mathrm{H}}R - c$, which is what they get by replacing the entrepreneur. Let θ^* be defined by

$$p_{\mathrm{H}}R - c \equiv \theta^* p_{\mathrm{H}}R \quad \text{or} \quad \theta^* \equiv 1 - \frac{c}{p_{\mathrm{H}}R}.$$

Suppose now that

$$\theta p_{\mathrm{H}}R < I < \theta^* p_{\mathrm{H}}R,$$

where θ is the lenders' bargaining power when they cannot seize the asset. Then the initial entrepreneur can find funding for the project provided she allows the lenders to seize the asset if they so desire.[45] We

41. See Kreps and Wilson (1982) and Milgrom and Roberts (1982) for a formalization of such behaviors.

42. See, for example, Osborne and Rubinstein's (1990) book for a review of models of bargaining with outside options.

43. The entrepreneur is hurt by her outside option if

$$\theta(p_{\mathrm{H}}R) \geqslant I > \theta'(p_{\mathrm{H}}R).$$

44. See Farrell and Gallini (1988) and Shepard (1987).

In practice, the replacement is often made by shareholders rather than debtholders. Recall, though, that in this basic model there is no difference between debt and equity, and so we do not have to worry about a possible dissonance between shareholders and debtholders regarding the replacement decision.

45. This contract leaves rent $\theta^* p_{\mathrm{H}}R - I > 0$ to the lenders. There are several ways for the entrepreneur to recoup this rent. First, she may

therefore conclude that *giving the lenders the right to seize the firm's assets may enable the entrepreneur to credibly commit not to expropriate the lenders*. In a sense, we are back to the idea that collateral pledging boosts debt capacity. The new insight here is simply that *the value of the collateral depends on how indispensable the entrepreneur is*.

Supplementary Sections

4.6 Group Lending and Microfinance

Borrowers with weak balance sheets (no cash, no adequate collateral, no guaranteed income streams) are unlikely to have access to sources of finance. A number of recent and apparently successful institutions have tried to strengthen the balance sheet of small borrowers by lending to groups rather than to individuals. A well-known example is the Grameen Bank in Bangladesh, but similar institutions exist in several developing countries. A comprehensive overview of institutions, incentive considerations, and empirical data in microfinance can be found in Armendáriz de Aghion and Morduch (2005).

The borrowers organize themselves in groups and each participant accepts joint responsibility for the loan. As in Section 4.2, there is cross-pledging among several projects, but here the projects are not projects of a single borrower, but rather projects of different borrowers.[46]

Group lending may at first sight seem surprising. We saw in Section 3.2.4 that a borrower should be made accountable only for outcomes that she can control. And if another borrower's performance is relevant because it conveys information and enables benchmarking, then the dependence of a borrower's reward on the other borrower's performance is generally negative; for example, if two nearby located farmers face similar climatic conditions, then benchmarking may enable the lenders to get information about whether a farmer's good or bad performance is related to effort or just luck. In that case, a farmer is at least partly compensated on the basis of relative performance. In contrast, under group lending, a borrower prefers the other borrowers to do well because of the joint liability. This supplementary section discusses the ways in which group lending can indeed strengthen the borrowers' balance sheets and thereby enable financing.

Group lending can be given two rationales, both of them closely related to themes developed in this chapter. First, group lending may make use of nonmonetary collateral, actually collateral that is per se valueless to the investors: the social capital within the group. Second, group lending may be based on peer monitoring. Members of the group may monitor the quality of the other members' projects *ex ante*, or once financing has been secured monitor each other's project management.

Both ideas will be illustrated using the context of two borrowers facing identical, fixed-investment projects (see Section 3.2). That is, each borrower has a project of size I and has limited cash on hand $A < I$. Projects succeed (yield R) or fail (yield 0). The probability of success is p_{H} if the entrepreneur behaves (but then receives no private benefit) and p_{L} if she misbehaves (and receives private benefit B). Assume universal risk neutrality and borrower limited liability.

The two projects are independent. In particular, there is no scope for benchmarking as a source of linkage between the two projects. We will assume that

$$p_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right) < I - A.$$

That is, the projects cannot be financed on a stand-alone basis. Furthermore, absent other considerations, linking the two projects contractually by making one borrower's compensation contingent on the other borrower's performance cannot alleviate the financing problem (see Section 3.4.2): because projects are unrelated, such a link could only garble individual performance measurement and increase the agency cost.

ask for some "downpayment." Concretely, this may take the form of incomplete investment of the entrepreneur's equity A if we introduced some (provided that $\theta^* p_{\mathrm{H}}R - I < 0$). Alternatively, the entrepreneur might specify that she keeps some share in the firm even in the event she is replaced.

46. The literature on group lending includes (but is far from being limited to) Armendáriz de Aghion (1999), Armendáriz de Aghion and Gollier (2000), Banerjee et al. (1994), Besley and Coate (1995), Ghatak and Guinnane (1999), Ghatak and Kali (2001), Laffont and N'Guessan (2000), Laffont and Rey (2000), Stiglitz (1990), and Varian (1990). See Ahlin and Townsend (2003a,b) for empirical work on selection into joint liability contracts.

(a) *Group lending: using social capital as collateral.* The theory of corporate finance focuses primarily, although not exclusively, on physical capital (assets, incomes). Capital can be given a broader meaning, some of which is relevant for our present concern. Relations among people matter substantially even in economic situations such as lending relationships. One view of group lending is that social capital can supplement an insufficient amount of physical capital and thereby facilitate financing. "Social capital" is a complex notion (see, for example, Chapter 12 in Coleman 1990), and we certainly will not do justice to it in this short section.

An important manifestation of social capital is the trust people of a group or community have in each other. Groups in which members trust each other achieve much more than other groups in which they don't. And quite importantly, members of a group value their reputation within the group, as they will be chosen for valuable interaction or given discretionary power if they are deemed trustworthy or reliable.

How can the lending relationship use this fact to increase the borrower's incentives to behave, given that misbehavior is relative to the lenders, and not to the members of the group? Under group lending, the borrower may be concerned that, if she misbehaves, not only will she be more likely to forgo the monetary reward, but also the others may then be upset and infer some "individualistic" tendency in her behavior.[47] They may question her altruism and again be reluctant to interact with her in the future (see Exercise 4.7).[48]

Let us here develop a simple version in which there is no asymmetric information about the agents' degree of altruism. Suppose that each borrower puts weight a ($a \leqslant 1$) on the other borrower's income relative to her own income. The parameter a is one of altruism (a was set equal to 0 until now).

Note that altruism has no effect if borrowers attempt to secure financing for their projects separately; for, assuming financing occurs, each borrower then correctly takes the other borrower's income as exogenous to her own behavior, and so the incentive constraint (which, recall, sets the level of the nonpledgeable income) remains:

$$(\Delta p)R_{\mathrm{b}} \geqslant B.$$

And so the projects do not receive financing.

Consider now group lending. The borrowers receive R_{b} each if *both* projects succeed and 0 otherwise. It is an equilibrium for both entrepreneurs to behave if

$$p_{\mathrm{H}}^2(R_{\mathrm{b}} + aR_{\mathrm{b}}) \geqslant p_{\mathrm{H}}p_{\mathrm{L}}(R_{\mathrm{b}} + aR_{\mathrm{b}}) + B$$

or

$$p_{\mathrm{H}}(R_{\mathrm{b}} + aR_{\mathrm{b}}) \geqslant \frac{B}{\Delta p}. \qquad (\mathrm{IC_b})$$

Crucially, the term "aR_{b}" in the incentive constraint plays the same role in the incentive constraint as did physical collateral (e.g., the family house that is turned over to investors in the case of failure) in Section 4.3. The *per-borrower* pledgeable income is now

$$p_{\mathrm{H}}R - p_{\mathrm{H}}^2\Big[\min_{\{\mathrm{IC_b}\}} R_{\mathrm{b}}\Big] = p_{\mathrm{H}}\Big(R - \frac{B}{(1+a)\Delta p}\Big).$$

The stronger the altruism (a), the higher the pledgeable income! In particular, if

$$p_{\mathrm{H}}\Big(R - \frac{B}{(1+a)\Delta p}\Big) \geqslant I - A,$$

financing becomes feasible.

(b) *Group lending: peer monitoring.* The competing rationale for group lending is, as we said, peer monitoring. Peer monitoring can occur at two stages: *ex ante* (before the investment decision) and *ex post* (after the investment decision). In either case, group lending is one way of eliciting the information that borrowers have about each other. *Ex ante*, entrepreneurs may have information about each other that is not available to lenders (as in, for example, Ghatak and Kali 2001). An entrepreneur's being willing to team up with another entrepreneur under a joint liability lending arrangement is good news about the ability or willingness of the latter to be successful.

47. Another channel of impact of social capital on lending relationships is that if the project fails and so the borrower does not pay the lenders back, the other members of the group may infer that the borrower is lazy, overly prone to favor her family or close friends, enjoys private benefits, and so on; the other members may therefore be reluctant in the future to engage in other forms of interaction with the borrower. While disclosure is an attempt to lever up social capital (in a sense, to free the lenders and borrower from the limited liability constraint), this story explains information sharing, but not group lending.

48. Che (2002) endogenizes the punishment behavior by introducing repeated interactions among group members.

Table 4.1

	good project	bad project	Bad project
Pr(success)	p_H	p_L	p_L
Private benefit	0	b	B

In other words, group lending alleviates the adverse-selection problem.[49]

Ex post, that is, after the financing has been committed, borrowers may monitor each other in a way lenders cannot mimic cheaply. For example, borrowers may have a comparative advantage in monitoring each other due to geographical proximity or a common technological expertise.

Let us consider the following mutual monitoring model (which will also be used in Chapter 9). After the investments are sunk, but before each entrepreneur's moral-hazard decision, each entrepreneur can monitor the other entrepreneur (the two monitoring decisions are made simultaneously and noncooperatively). So each entrepreneur has two roles: that of a monitor (for the other's project) and that of a monitoree (for her own project). To formalize the idea that monitoring reduces the extent of moral hazard, assume that a monitor can reduce the private benefit that can be enjoyed by the monitoree by shirking from B to $b < B$. The monitor must, however, bear an unobservable private monitoring cost $c > 0$ in order to achieve this reduction in private benefit.

An interpretation of this monitoring structure is as described in Table 4.1. Each entrepreneur will have to choose among a number of *ex ante* identical projects (the set of projects are different for the two entrepreneurs). The entrepreneur privately learns the payoffs attached to each project. There are three relevant projects: (1) the good project, which yields no private benefit and has probability of success p_H; (2) the low-private-benefit bad project, which yields private benefit b and has probability of success p_L; and (3) the high-private-benefit Bad project, which yields private benefit B and has probability of success p_L. The monitor moves first. If she incurs effort cost c, she is able to identify the other entrepreneur's high-private-benefit Bad project and thus to prevent the other entrepreneur from selecting it, say, by telling the investors about it (under group lending and in the absence of altruism and collusion, it will indeed be in the monitor's interest to report this information). But she still cannot tell the other two projects apart, and so the monitoree can still choose the low-private-benefit bad project if she wishes so. The monitor learns nothing when she does not incur the monitoring cost c; then, because the projects are still indistinguishable by the investors, the monitoree can choose any of the three projects as in the absence of monitoring (of course, the low-private-benefit bad project is then dominated for the entrepreneur and is irrelevant).

For expositional simplicity only, we will assume that

$$b = c$$

(this assumption says that moral hazard is equally strong along its two dimensions and makes the model "symmetric").

Let us investigate the conditions under which group lending and peer monitoring facilitate the entrepreneur's access to funds.[50] Suppose the entrepreneurs monitor each other and behave. A group lending contract that gives them R_b each if both projects succeed and 0 otherwise yields to each entrepreneur utility

$$p_H^2 R_b - c.$$

By failing either to monitor or to behave (but not both), an entrepreneur reduces the probability of success of the other project or of her project from p_H to p_L, and obtains

$$p_H p_L R_b = p_H p_L R_b - c + b.$$

Our first incentive compatibility constraint is therefore

$$p_H R_b \geqslant \frac{b}{\Delta p} = \frac{c}{\Delta p}.$$

49. This reduction in adverse selection can be studied using the techniques developed in Chapter 6.

50. We will assume that the entrepreneurs do not collude with each other. Extensive analyses of the impact of collusion on monitoring in corporate finance can be found in Dessi (2005) and, in the context of group lending, Laffont and Rey (2000). Laffont and Meleu (1997) emphasize the role of peer monitoring as creating possible side transfers for agents to collude in situations where other forms of side transfers are not readily available.

Note also that even if they do not collude, the two entrepreneurs might "coordinate" on an equilibrium in which they do not monitor each other.

It must also be the case that the entrepreneur does not want to misbehave on both fronts:

$$p_{\mathrm{H}}^2 R_{\mathrm{b}} - c \geqslant p_{\mathrm{L}}^2 R_{\mathrm{b}} + b$$

or

$$(p_{\mathrm{H}} + p_{\mathrm{L}}) R_{\mathrm{b}} \geqslant \frac{b + c}{\Delta p}. \qquad (\mathrm{IC_b})$$

As in our study of diversification (Section 4.2), the binding constraint is the latter one (since $(p_{\mathrm{H}} + p_{\mathrm{L}}) < 2p_{\mathrm{H}}$). Thus, the pledgeable income per project is

$$p_{\mathrm{H}} R - p_{\mathrm{H}}^2 \Big[\min_{\{\mathrm{IC_b}\}} R_{\mathrm{b}}\Big] = p_{\mathrm{H}} R - \frac{p_{\mathrm{H}}^2}{p_{\mathrm{H}}^2 - p_{\mathrm{L}}^2}(b + c).$$

The pledgeable income has increased relative to the case of separate financing if and only if

$$\frac{p_{\mathrm{H}}^2}{p_{\mathrm{H}}^2 - p_{\mathrm{L}}^2}(b + c) < \frac{p_{\mathrm{H}} B}{\Delta p}$$

or

$$\left(\frac{p_{\mathrm{H}}}{p_{\mathrm{H}} + p_{\mathrm{L}}}\right)(b + c) < B.$$

Thus if the monitoring cost (equal here to the low private benefit) is low enough relative to the high private benefit, peer monitoring facilitates access to funds. Intuitively, joint liability creates an incentive for cross-monitoring provided that the monitoring cost is small. While monitoring per se is wasteful, it is worth inducing as long as it generates a substantial reduction in private benefit ($B - b$) from misbehavior and provided that funding cannot be secured under project finance (as has been assumed here). Joint liability can thus be added to our list of concessions made by borrowers in order to secure financing.

4.7 Sequential Projects

As announced in Section 4.2.4 we investigate the impact of sequentiality on borrowing capacity and NPV in the context of diversified projects. We do so in the variable-investment context, which requires a straightforward extension of Section 4.2 to this environment.

4.7.1 Benchmark: Simultaneous Diversification

As in Section 4.2, assume that the entrepreneur may undertake two independent projects and that the outcomes are realized only after efforts have been exerted (and so the financing of the second project cannot be made contingent on the outcome of the first). We, however, assume that the technology is the constant-returns-to-scale one studied in Section 3.4. We proceed rather sketchily since the analysis is almost identical to the fixed-investment one of Section 4.2.1. A project $i \in \{1, 2\}$ of size I_i yields revenue RI_i with probability p, where $p = p_{\mathrm{H}}$ if the entrepreneur behaves (no private benefit) and $p = p_{\mathrm{L}}$ if the entrepreneur misbehaves (private benefit BI_i). Let

$$I \equiv I_1 + I_2$$

denote the total investment.

As in Section 4.2, risk neutrality implies that it is optimal to reward the entrepreneur only when both projects succeed. Let R_{b} denote this reward. As in Section 4.2.1, there are two incentive constraints, but the binding one relates to misbehavior on both projects:

$$p_{\mathrm{H}}^2 R_{\mathrm{b}} \geqslant p_{\mathrm{L}}^2 R_{\mathrm{b}} + BI.$$

Hence, maximizing the NPV subject to the investors' breakeven constraint can be written as

$$U_{\mathrm{b}}^{\text{simultaneous}} = \max (p_{\mathrm{H}} R - 1) I$$

s.t.

$$p_{\mathrm{H}} RI - p_{\mathrm{H}}^2 \left[\frac{BI}{p_{\mathrm{H}}^2 - p_{\mathrm{L}}^2}\right] = I - A.$$

And so

$$I = \frac{A}{1 - \hat{\rho}_0},$$

where

$$\hat{\rho}_0 \equiv p_{\mathrm{H}}\left[R - \frac{p_{\mathrm{H}}}{p_{\mathrm{H}} + p_{\mathrm{L}}} \frac{B}{\Delta p}\right] = p_{\mathrm{H}}\left[R - (1 - d_2)\frac{B}{\Delta p}\right],$$

using the notation of Section 4.2.1.

The entrepreneur does not want to misbehave on project i if and only if

$$p_{\mathrm{H}}^2 R_{\mathrm{b}} \geqslant p_{\mathrm{H}} p_{\mathrm{L}} R_{\mathrm{b}} + BI_i,$$

or, after some manipulations,

$$\frac{p_{\mathrm{H}}}{p_{\mathrm{H}} + p_{\mathrm{L}}} \geqslant \frac{I_i}{I} \quad \text{for } i \in (1, 2).$$

This constraint is satisfied as long as the investment is split relatively equally between the two projects (for example, it is strictly satisfied for $I_i = \frac{1}{2}I$), but not if all or most eggs are put into the same basket (as in the case when I_1, say, is close to I): benefits from diversification are largest when the investment is indeed split across projects.

4.7.2 Long-Term Finance and the Build-up of Net Worth

Let us now consider the sequential case, in which the outcome of the first project is known before investment is sunk in the second project: project 1 and its realization occur at date 1, project 2 and its realization at date 2. To make the simultaneous and sequential cases comparable, we assume that there is no discounting between the two periods. We initially assume that the first loan agreement covers only the first project, and study how the build-up of equity motivates the entrepreneur. We then analyze the optimal long-term contract and ask whether there is scope for lender commitment of future financing.

4.7.2.1 Short-Term Loan Agreements: The Increasing-Stake Result

To conduct a credit analysis in period 1, the lenders must see through the borrower's incentives to build up equity. So, they must work *backwards* and compute the borrower's gross utility in period 2 when she goes to the capital market to finance the date-2 (variable size) project with arbitrary assets A_2. In Section 3.4, we showed that this gross utility is

$$vA_2,$$

where $v > 1$ is the shadow value of equity given by equation (3.14′):

$$v = \frac{\rho_1 - \rho_0}{1 - \rho_0},$$

where

$$\rho_1 \equiv p_{\mathrm{H}}R$$

denotes the expected payoff per unit of investment, and

$$\rho_0 \equiv p_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right)$$

denotes the expected pledgeable income per unit of investment.

Consider now the date-1 project. Suppose that the corresponding loan agreement specifies (a) an investment level I_1 and (b) a sharing rule in the case of success, R_{b} for the borrower and R_{l} for the lenders.[51] As in the static case, it is easy to show that the optimal date-1 contract specifies a reward for the entrepreneur only when the project succeeds. Letting $A_1 = A$ denote the borrower's initial cash endowment, the date-1 investors' breakeven constraint is as usual given by

$$p_{\mathrm{H}}R_{\mathrm{l}} \geqslant I_1 - A. \tag{IR$_\mathrm{l}$}$$

The incentive constraint is slightly modified due to the existence of the shadow value of equity:

$$(\Delta p)[v(RI_1 - R_{\mathrm{l}})] \geqslant BI_1. \tag{IC$_\mathrm{b}$}$$

The analysis is identical to that in Section 3.4, except for the existence of this shadow value (which amounts to replacing "B" by "B/v"). The pledgeable income per unit of investment becomes

$$\tilde{\rho}_0 = p_{\mathrm{H}}\left(R - \frac{B}{v\Delta p}\right) = \rho_1 - \frac{\rho_1 - \rho_0}{v} = \rho_1 + \rho_0 - 1.$$

The date-1 debt capacity is therefore given by $I_1 = k_1 A$, where[52]

$$k_1 = \frac{1}{1 - \tilde{\rho}_0} = \frac{1}{2 - \rho_0 - \rho_1} > k = \frac{1}{1 - \rho_0}. \tag{4.11}$$

Under short-term loan agreements, the borrower invests in period 2 if and only if she has income, that is, if and only if the first project is successful. She then invests

$$I_2^{\mathrm{S}} = kA_2^{\mathrm{S}} = \frac{A_2^{\mathrm{S}}}{1 - \rho_0},$$

where A_2^{S} is her date-2 equity in the case of date-1 success:

$$A_2^{\mathrm{S}} = RI_1 - R_{\mathrm{l}} = \frac{BI_1}{(\Delta p)v}.$$

After some computations, one finds that the (date-1) expected second-period investment is equal to the first-period investment:

$$p_{\mathrm{H}}I_2^{\mathrm{S}} = I_1.$$

Our first result is that *stakes increase over time*: conditional on proper performance, the second-period investment is $1/p_{\mathrm{H}} > 1$ times the first-period investment. The split of investment occurs only in expectations.

51. Strictly speaking, it is not necessary that the income attached to the first project be realized in period 1. In particular, it could be the case that this income accrues only in period 2. If a signal accrues at the end of date 1 that is a sufficient statistic for the probability of success and is public information, the future proceeds from the date-1 project can be sold in the marketplace, that is, *securitized*, and everything is as if the income accrued at date 1.

52. We assume that the denominator of k_1 is positive. Otherwise, the debt capacity in period 1 is infinite.

The borrower's *gross* utility under short-term loan agreements, $U_{\mathrm{b}}^{\mathrm{g,ST}}$, is

$$U_{\mathrm{b}}^{\mathrm{g,ST}} = p_{\mathrm{H}}[\upsilon A_2^{\mathrm{S}}] = \frac{\rho_1 - \rho_0}{2 - \rho_0 - \rho_1} A.$$

This yields a *net* borrower utility:

$$U_{\mathrm{b}}^{\mathrm{ST}} \equiv U_{\mathrm{b}}^{\mathrm{g,ST}} - A = \frac{2(\rho_1 - 1)}{2 - \rho_0 - \rho_1} A, \tag{4.12}$$

which, we check, is nothing but the NPV:

$$\mathrm{NPV} = (\rho_1 - 1)(I_1 + p_{\mathrm{H}} I_2^{\mathrm{S}})$$

since $p_{\mathrm{H}} I_2^{\mathrm{S}} = I_1 = A/(2 - \rho_0 - \rho_1)$.

We can draw two further conclusions from this analysis.

The prospect of follow-up projects is a disciplining device. Consequently, the first-period borrowing capacity is larger than in the absence of such projects (see (4.11)). The lenders trust the borrower more because the latter attaches a shadow value (in excess of 1) to retained earnings.

Because of the nature of a short-term loan agreement, the borrower is unable to continue if the first project fails. There is therefore *no insurance* concerning the financing of the second-period project. We now ask whether such insurance should be supplied in a long-term loan agreement.

4.7.2.2 Long-Term Loan Agreements and Credit Commitments

Suppose now that the date-1 contract between the lenders and the borrower specifies (a) the date-1 investment I_1, (b) the date-2 investment I_2 contingent on whether the first project failed or succeeded, and (c) the sharing of the first- and second-period incomes.

Obviously, the borrower is always weakly better off under a long-term contract because she can always obtain the short-term contract outcome by duplicating what would have happened under a sequence of short-term contracts. So, the question is whether the borrower can *strictly* gain by signing a long-term contract.

Let us first derive the optimal long-term contract in our constant-returns-to-scale model. Let us assume that the first-period investment is I_1, and that the first-period income is split into R_{b} and $R_{\mathrm{l}} = RI_1 - R_{\mathrm{b}}$. The second-period net utilities for the borrower are V_2^{S} and V_2^{F}, where the superscripts "S" and "F" indicate that the date-1 project succeeded or failed. Similarly, the date-2 utilities for the lenders are W_2^{S} and W_2^{F}. Without loss of generality we can assume that R_{b} is consumed (rather than reinvested) by the borrower: if part of R_{b} were reinvested, one could equivalently reallocate this part to the lenders, whose contribution towards defraying the cost of the second-period investment would increase accordingly.

We necessarily have

$$V_2^k + W_2^k = (p_{\mathrm{H}} R - 1) I_2^k, \quad k = \mathrm{S, F}. \tag{4.13}$$

Furthermore, incentive compatibility in period 2 requires that

$$V_2^k \geqslant \frac{p_{\mathrm{H}} B}{\Delta p} I_2^k, \quad k = \mathrm{S, F}. \tag{4.14}$$

Thus we want to maximize the borrower's net intertemporal utility:

$$\max U_{\mathrm{b}} = p_{\mathrm{H}}(R_{\mathrm{b}} + V_2^{\mathrm{S}}) + (1 - p_{\mathrm{H}}) V_2^{\mathrm{F}} - A \tag{4.15}$$

subject to (4.13), (4.14), to the incentive compatibility condition in period 1,

$$(\Delta p)(R_{\mathrm{b}} + V_2^{\mathrm{S}} - V_2^{\mathrm{F}}) \geqslant B I_1, \tag{4.16}$$

and to the breakeven constraint,

$$p_{\mathrm{H}}[RI_1 - R_{\mathrm{b}} + W_2^{\mathrm{S}}] + (1 - p_{\mathrm{H}}) W_2^{\mathrm{F}} = I_1 - A. \tag{4.17}$$

We leave it to the reader to analyze this program.[53] Solving it shows that the date-1 and date-2 investments are the same as under short-term contracting,

$$I_1 = \frac{A}{2 - \rho_0 - \rho_1}, \qquad I_2^{\mathrm{S}} = \frac{I_1}{p_{\mathrm{H}}}, \qquad I_2^{\mathrm{F}} = 0,$$

and that the borrower's utility is also the same as under short-term contracting,

$$U_{\mathrm{b}}^{\mathrm{g,LT}} = \frac{2(\rho_1 - \rho_0)}{2 - \rho_0 - \rho_1} A = U_{\mathrm{b}}^{\mathrm{g,ST}}.$$

Thus, *the borrower obtains the same intertemporal utility as under short-term loan agreements if the technology exhibits constant returns to scale.*

53. One may proceed as follows. (i) One can show that, without loss of generality, $R_{\mathrm{b}} = 0$ (the borrower might as well reinvest earnings rather than consume them). (ii) Substituting (4.13) into (4.17) to eliminate the W_2^k, one sees that (4.14) must be binding for $k = \mathrm{S, F}$ (otherwise, one would increase the date-2 investments). (iii) One then shows that there is no loss of generality in taking $V_2^{\mathrm{F}} = I_2^{\mathrm{F}} = 0$. (iv) Lastly, using (4.17) and (4.14), and showing that (4.16) is binding, one obtains $p_{\mathrm{H}} I_2^{\mathrm{S}} = I_1$. The conclusions then follow.

This equivalence between short- and long-term contracts which extends to an arbitrary number of projects is striking, although it relies crucially on risk neutrality.[54]

4.7.2.3 Comparison: The Impact of Sequentiality

Finally, we compare the entrepreneur's net payoffs (the NPVs) in the simultaneous and sequential cases:

$$U_{\mathrm{b}}^{\text{simultaneous}} = \frac{\rho_1 - 1}{1 - \hat{\rho}_0} A < U_{\mathrm{b}}^{\text{sequential}} = \frac{2(\rho_1 - 1)}{2 - \rho_0 - \rho_1} A$$

if and only if

$$1 - \hat{\rho}_0 > \frac{2 - \rho_0 - \rho_1}{2} \iff 2 > \rho_1 + \rho_0,$$

which is indeed satisfied. Thus, the entrepreneur is better off under sequential projects. Intuitively, sequentiality alleviates moral hazard: the entrepreneur cannot take her private benefit on the second project if the first project fails. By contrast, she can do so when projects are simultaneous; the disciplining threat of nonrefinancing is then empty.

We can also point at the impact of project correlation. It was argued in Section 4.2 that when projects are simultaneous, correlation reduces the pledgeable income and ultimately hurts the entrepreneur. Correlation is more of a mixed blessing in the case of sequential projects; for, a failure in the first project (which has positive probability unless $p_{\mathrm{H}} = 1$) is informative about the payoff to the second project. Put differently, correlation would generate a learning effect that is beneficial whether there is an agency problem or not. With an agency cost, it is *a fortiori* optimal not to fund the second project if the first project fails. The second project is, however, funded on a larger scale if the first project succeeds.[55]

54. Principal–agent theory has investigated conditions under which the optimal long-term contract between a principal and an agent can be implemented through a sequence of short-term contracts. See Chiappori et al. (1994) for a very clear exposition.

55. Under perfect correlation, and assuming that the optimal incentive scheme induces good behavior at date 1 (which is not a foregone conclusion, since the learning benefit might be stronger under misbehavior), the posterior probabilities of success under good and bad behaviors are $\hat{p}_{\mathrm{H}} = 1$ and $\hat{p}_{\mathrm{L}} = p_{\mathrm{L}}/p_{\mathrm{H}}$, respectively. And so the second-period incentive constraint following a first-period success can be written as

$$(\hat{p}_{\mathrm{H}} - \hat{p}_{\mathrm{L}})R_{\mathrm{b}} \geqslant BI_2 \iff \hat{p}_{\mathrm{H}}R_{\mathrm{b}} \geqslant \frac{p_{\mathrm{H}}BI_2}{\Delta p}.$$

The nonpledgeable income at date 2 is thus the same (for a given investment) as when the projects are independent. But the NPV, $\hat{p}_{\mathrm{H}}RI_2$, and therefore the pledgeable income are higher due to the learning effect.

4.7.3 Continuation versus Financial Incentives in Infinite-Horizon Models

As the previous two-period model demonstrated, managerial incentives can be provided either through the promise of continuation or the threat of termination[56] or through financial compensation. Continuation is under entrepreneurial risk neutrality a more efficient "carrot" than financial rewards whenever continuation has a positive NPV: the same incentive can then be provided at a lower cost to investors, or, conversely, the same pledgeable income is consistent with a higher entrepreneurial payoff.

The two-period setup, however, leaves aside some interesting issues. First, it provides little insight into the potentially complex dynamics of retentions and refinancing under a longer horizon. Second, in the two-period version, the obviously efficient design of incentives rewards the entrepreneur with pure continuation (no financial reward) in the first period and a purely financial reward in the second period. With an infinite horizon, continuation is always an option and always more efficient (yields a higher NPV) than a financial reward; yet, the manager must at some point cash in if successful. This dual pattern of retentions and comovement of the continuation and financial rewards incentives is addressed in two papers by DeMarzo and Fishman (2002) and by Biais, Mariotti, Plantin, and Rochet (2004), which both assume an infinite horizon $t = 0, 1, \dots$.[57] While covering these papers lies outside the scope of this book, we can point at a few of their insights.

Biais et al. (2004) consider a stationary environment in which the per-period (recurrent) investment has a fixed size and pledgeable income in each period is smaller than the per-period reinvestment cost:

$$p_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right) < I.$$

The only element of nonstationarity may stem from a date-0 up-front investment cost I_0 which takes an arbitrary value (and therefore may largely exceed the continuation or reinvestment cost I).

56. Or, more generally, the prospect of upsizing or downsizing.

57. See also Gromb (1999) and Clementi and Hopenhayn (2002) for related work.

$0 \qquad \mathcal{U}_{\mathrm{b}}^{***} \qquad \mathcal{U}_{\mathrm{b}}^{**} \qquad \mathcal{U}_{\mathrm{b}}^{*} \qquad \mathcal{U}_{\mathrm{b}}(t) \longrightarrow$

Probability of continuation $x(t)$	$0 \leqslant \dfrac{\mathcal{U}_{\mathrm{b}}}{\mathcal{U}_{\mathrm{b}}^{***}} \leqslant 1$	1	1	1 (actually, $x(t+\tau) = 1$ for all $\tau \geqslant 0$)
Flow financial payment in the case of success $R_{\mathrm{b}}(t)$	0	0	$\mathcal{U}_{\mathrm{b}}(t) - \mathcal{U}_{\mathrm{b}}^{**}$	$\dfrac{B}{\Delta p}$
Flow financial payment in the case of failure	0	0	0	0
Continuation value $\mathcal{U}_{\mathrm{b}}(t+1)$	greater than $\mathcal{U}_{\mathrm{b}}^{***}/\beta$ if success 0 (liquidation) if failure	greater than $\mathcal{U}_{\mathrm{b}}(t)/\beta$ if success lower than $\mathcal{U}_{\mathrm{b}}(t)/\beta$ if failure	$\mathcal{U}_{\mathrm{b}}^{*}$ if success lower than $\mathcal{U}_{\mathrm{b}}(t)/\beta$ if failure	$\mathcal{U}_{\mathrm{b}}^{*}$

Figure 4.6

In each period t, the firm either continues, implying reinvestment cost I, or is liquidated. If it continues, the manager chooses effort ($p = p_{\mathrm{H}}$ or p_{L}, where misbehavior yields an instantaneous private benefit B); finally, the date-t performance (profit R in the case of success, 0 in the case of failure) is observed at the end of period t.

The entrepreneur and the investors are risk neutral, with preferences

$$E\left[\sum_{t=0}^{\infty} \beta^t c_t\right],$$

where β is the discount factor (smaller than 1) and c_t is the agent's date-t consumption (which, for the entrepreneur, may include the private benefit B if she elects to misbehave at date t). The entrepreneur is, as usual, protected by limited liability.

As is standard in repeated-moral-hazard models (see, for example, Chiappori et al. 1994; Spear and Srivastava 1987), the optimal contract is best characterized through the state-independent expected continuation valuation of the entrepreneur. Thus, let $\mathcal{U}(t)$ denote the expected present discounted utility of the entrepreneur at date t; this value function depends on the history up to date t and turns out to be a "sufficient statistic" for the future starting at date t.

Figure 4.6 describes the optimal combination of continuation and financial incentives. It confirms that the entrepreneur is first rewarded through continuation or, equivalently, deterred by the threat of termination (or downsizing: the probability $x(t)$ of continuation can also be interpreted, when investment is continuous (but bounded above), as the fraction of assets that are not liquidated).

Indeed, as long as the value function does not exceed level $\mathcal{U}_{\mathrm{b}}^{**}$, no payment is made to the entrepreneur. Payments occur only when the value function is high, that is, when the past performance has been satisfactory (intuitively, enough milestones have been reached).

Turning to the implementation of the optimal contract, Biais et al. show that it can be implemented by giving investors stocks and bonds claims and that payouts can be made contingent solely on the size of accumulated reserves $L(t)$. There exist thresholds $L^{***} < L^{**} < L^{*}$ (corresponding to value function thresholds $\mathcal{U}_{\mathrm{b}}^{***} < \mathcal{U}_{\mathrm{b}}^{**} < \mathcal{U}_{\mathrm{b}}^{*}$) such that, in particular,

- for $L(t) \geqslant L^{*}$, stocks pay a dividend;
- for $L(t) \geqslant L^{***}$, bonds distribute their full coupon;
- for $L(t) \leqslant L^{***}$, the firm cannot meet its debt payment and enters financial distress. It is downsized by a factor $L(t)/L^{***}$ (and then keeps operating on a smaller scale if it exits distress).

The date-0 financing contract sets the initial financial cushion $L(0)$ and the entrepreneur receives shares in the firm (as in the two-period model).

DeMarzo and Fishman (2002) perform a similar analysis, but in a generalized "Bolton–Scharfstein framework" (see Section 3.8) in which the investors cannot observe the cash flows. The moral-hazard dimension then refers to the entrepreneur's concealing realized cash flow rather than taking actions that may jeopardize these cash flows. When diverting 1, the manager receives $k \leqslant 1$ (in a sense, $k = B/\Delta p$ in Biais et al., and so, even if the income is verifiable in Biais et al. and nonverifiable in DeMarzo and Fishman, the models are mathematically very similar). DeMarzo and Fishman emphasizes an implementation in terms of a long-term coupon debt and a credit line. The credit line provides flexibility for the entrepreneur to accommodate, for a limited time, the adverse shocks that may arise under a random cash flow. (We will return to credit lines in Chapters 5 and 15.)

4.8 Exercises

Exercise 4.1 (maintenance of collateral and asset depletion just before distress). This exercise analyzes the impact of the existence of a privately received signal about distress on credit rationing. Consider the model of Section 4.3.4 with $A' = A$ (so the asset has the same value for the borrower and the lender). The new feature is that the resale value of the asset is A only if the borrower invests in maintenance; otherwise the final value of the asset is 0, regardless of the state of nature. The loan agreement cannot monitor the borrower's maintenance decision (but the resale value is verifiable). So, there are two dimensions of moral hazard for the borrower. The borrower incurs private disutility $c < A$ from maintaining the asset, and 0 from not maintaining it. Assume that $p_{\mathrm{L}}B/(\Delta p) \geqslant c$, and that the entrepreneur is protected by limited liability.

(i) Suppose that the borrower receives no signal about the likelihood of distress (that is, the maintenance decision can be thought of as being simultaneous with that of choosing between probabilities p_{H} and p_{L} of success). Show that the analysis of this chapter is unaltered except that the borrower's utility U_{b} is reduced by c.

(ii) Suppose now that with probability ξ in the case of failure the borrower privately learns that failure will occur with certainty. With probability $(1-\xi)$ in the case of failure and with probability 1 in the case of success, no signal accrues. ($\xi = 0$ corresponds to question (i).) The signal, if any, is received after the choice between p_{H} and p_{L} but before the maintenance decision. Suppose further that the asset is pledged to the lenders only in the case of failure. Show that, if the entrepreneur is poor and c is "not too large," constraint ($\mathrm{IC_b}$) must now be written

$$(\Delta p)(R_{\mathrm{b}} + A) \geqslant B + (\Delta p)\xi c.$$

Interpret this inequality. Find a necessary and sufficient condition for the project to be funded.

(iii) Keeping the framework of question (ii), when is it better not to pledge the asset at all than to pledge it in the case of failure?

Exercise 4.2 (diversification across heterogeneous activities). Consider two variable-investment activities, α and β, as described in Section 3.4. The probabilities of success p_{H} (when working) and p_{L} (when shirking) are the same in both activities. The two activities are independent (as in Section 4.2). The two activities differ in their per-unit returns (R^{α} and R^{β}) and private benefits (B^{α} and B^{β}). Let, for $i \in \{\alpha, \beta\}$,

$$\rho_1^i \equiv p_{\mathrm{H}} R^i > 1 \quad \text{and} \quad \rho_0^i = p_{\mathrm{H}}\left(R^i - \frac{B^i}{\Delta p}\right) < 1.$$

For example, $\rho_1^{\alpha} < \rho_1^{\beta}$ but $\rho_0^{\alpha} > \rho_0^{\beta}$.

(i) Suppose that the entrepreneur agrees with the investors to *focus* on a single activity. Which activity will they choose?

(ii) Assume now that the firm invests I^{α} in activity α and I^{β} in activity β and that this allocation can be contracted upon with the investors. Write the incentive constraints and breakeven constraint.

Show that it may be that the optimum is to invest more in activity β ($I^{\beta} > I^{\alpha}$) even though the entrepreneur would focus on activity α if she were forced to focus.

Exercise 4.3 (full pledging). In Section 4.3.1, we claimed that it is optimal to pledge the full value of the resale in the case of distress before committing any of the income R obtained in the absence of distress. Prove this formally.

Exercise 4.4 ("value at risk" and benefits from diversification). This exercise looks at the impact of portfolio correlation on capital requirements. An entrepreneur has two identical fixed-investment projects. Each involves investment cost I. A project is successful (yields R) with probability p and fails (yields 0) with probability $1 - p$. The probability of success is endogenous. If the entrepreneur works, the probability of success is $p_{\mathrm{H}} = \frac{1}{2}$ and the entrepreneur receives no private benefit. If the entrepreneur shirks, the probability of success is $p_{\mathrm{L}} = 0$ and the entrepreneur obtains private benefit B. The entrepreneur starts with cash $2A$, that is, A per project.

We assume that the probability that one project succeeds conditional on the other project succeeding (and the entrepreneur behaving) is

$$\tfrac{1}{2}(1 + \alpha)$$

(it is, of course, 0 if the entrepreneur misbehaves on this project). $\alpha \in [-1, 1]$ is an index of correlation between the two projects.

The entrepreneur (who is protected by limited liability) has the following preferences:

$$u(R_{\mathrm{b}}) = \begin{cases} R_{\mathrm{b}} & \text{for } R_{\mathrm{b}} \in [0, \bar{R}], \\ \bar{R} & \text{for } R_{\mathrm{b}} \geqslant \bar{R}. \end{cases}$$

(i) Write the two incentive constraints that will guarantee that the entrepreneur works on both projects.

(ii) How is the entrepreneur optimally rewarded for $\bar{R}$ large?

(iii) Find the optimal compensation scheme in the general case. Distinguish between the cases of positive and negative correlation. How is the ability to receive outside funding affected by the coefficient of correlation?

Exercise 4.5 (liquidity of entrepreneur's claim). (i) Consider the framework of Section 4.4 (without speculative monitoring). In Section 4.4, we assumed that none of the value μr_{b} (with $\mu > 1$) obtained by reinvesting r_{b} was appropriated by the entrepreneur. Assume instead that $\mu_0 r_{\mathrm{b}}$ is returned to investors, where $\mu_0 < 1$. For consistency, assume that investors observe whether the entrepreneur faces a liquidity shock (this corresponds to case (a) in Section 4.4). And, to avoid having to consider the correlation of activities and the question of diversification (see Section 4.2), assume that $(\mu - \mu_0) r_{\mathrm{b}}$ is a private benefit that automatically accrues to the entrepreneur and therefore cannot be "cross-pledged."

There is an equivalence between rewarding success with payment R_{b} when there was no interim investment opportunity and rewarding success with $(1 - \lambda) R_{\mathrm{b}}$ independently of interim investment opportunity. As in Section 4.4 we assume that the entrepreneur is rewarded with R_{b} only when there was no interim investment opportunity.

How is the liquidity of the entrepreneur's claim affected by $\mu_0 > 0$?

(ii) Suppose now that the probability of a "liquidity shock," i.e., a new investment opportunity, is endogenous. If the entrepreneur does not search, then $\lambda = 0$; if she searches, which involves private cost $\bar{\lambda} c$ for the entrepreneur, then $\lambda = \bar{\lambda}$. Rewrite the financing constraint.

Exercise 4.6 (project size increase at an intermediate date). An entrepreneur has initial net worth A and starts at date 0 with a fixed-investment project costing I. The project succeeds (yields R) or fails (yields 0) with probability $p \in \{p_{\mathrm{L}}, p_{\mathrm{H}}\}$. The entrepreneur obtains private benefit B at date 0 when misbehaving (choosing $p = p_{\mathrm{L}}$) and 0 otherwise. Everyone is risk neutral, investors demand a 0 rate of return, and the entrepreneur is protected by limited liability.

The twist relative to this standard fixed-investment model is that, with probability λ, the size may be doubled *at no additional cost* to the investors (i.e., the project duplicated) at date 1. The new investment is identical with the initial one (same date-2 stochastic revenue; same description of moral hazard, except that it takes place at date 1) and is perfectly correlated with it. That is, there are three states of nature: either both projects succeed independently of the entrepreneur's effort, or both fail independently of effort, or a project for which the entrepreneur behaved succeeds and the other for which she misbehaved fails.

Denote by R_{b} the entrepreneur's compensation in the case of success when the reinvestment opportunity does not occur, and by $\mathcal{R}_{\mathrm{b}}$ that when both the initial and the new projects are successful. (The entrepreneur optimally receives 0 if any activity fails.)

Show that the project and its (contingent) duplication receive funding if and only if

$$(1+\lambda)\left[p_{\mathrm{H}}\left(R-\frac{B}{\Delta p}\right)\right] \geqslant I-A.$$

Exercise 4.7 (group lending and reputational capital). Consider two economic agents, each endowed with a fixed-investment project, as described, say, in Section 3.2. The two projects are independent.

Agent i's utility is

$$R_{\mathrm{b}}^{i}+aR_{\mathrm{b}}^{j},$$

where R_{b}^{i} is her income at the end of the period, R_{b}^{j} is the other agent's income, and $0<a<1$ is the parameter of altruism. Assume that

$$p_{\mathrm{H}}\left(R-\frac{B}{(1+a)\Delta p}\right)<I-A<p_{\mathrm{H}}R.$$

(i) Can the agents secure financing through individual borrowing? Through group lending?

(ii) Now add a later or "stage-2" game, which will be played after the outcomes of the two projects are realized. This game will be played by the two agents and will not be observed by the "stage-1" lenders. In this social game, which is unrelated to the previous projects, the two agents have two strategies C (cooperate) and D (defect). The *monetary* (not the utility) payoffs are given by the following payoff matrix:

		Agent 1	
		C	D
Agent 2	C	1, 1	−2, 2
	D	2, −2	−1, −1

(the first number in an entry is agent 1's monetary payoff and the second agent 2's payoff).

Suppose $a=\frac{1}{2}$. What is the equilibrium of this game? What would the equilibrium be if the agents were selfish ($a=0$)?

(iii) Now, assemble the two stages considered in (i) and (ii) into a single, two-stage dynamic game. Suppose that the agents in stage 1 (the corporate finance stage) are slightly unsure that the other agent is altruistic: agent i's beliefs are that, with probability $1-\varepsilon$, the other agent (j) is altruistic ($a^{j}=\frac{1}{2}$) and, with probability ε, the other agent is selfish ($a^{j}=0$). For simplicity, assume that ε is small (actually, it is convenient to take the approximation $\varepsilon=0$ in the computations).

The two agents engage in group lending and receive R_{b} each if both projects succeed and 0 otherwise. Profits and payments to the lenders are realized at the end of stage 1.

At stage 2, each agent decides whether to participate in the social game described in (ii). If either refuses to participate, each gets 0 at stage 2 (whether she is altruistic or selfish); otherwise, they get the payoffs resulting from equilibrium strategies in the social game.

Let δ denote the discount factor between the two stages. Compute the minimum discount factor that enables the agents to secure funding at stage 1.

Exercise 4.8 (peer monitoring). The peer monitoring model studied in the supplementary section assumes that the projects are independent. Suppose instead that they are (perfectly) correlated. (See Sections 3.2.4 and 4.2. There are three states of nature: favorable (both projects always succeed), unfavorable (both projects always fail), and intermediate (a project succeeds if and only if the entrepreneur behaves), with respective probabilities p_{L}, $1-p_{\mathrm{H}}$, and Δp.)

(i) Replace the limited liability assumption by {no limited liability, but strong risk aversion for $R_{\mathrm{b}}<0$ and risk neutrality for $R_{\mathrm{b}}\geqslant 0$}. Show that group lending is useless and that there is no credit rationing.

(ii) Come back to the limited liability assumption and assume that

$$p_{\mathrm{H}}\left(R-\frac{B}{\Delta p}\right)<I-A.$$

Assume that $b+c<B$. Find a condition under which the agents can secure funding.

Exercise 4.9 (borrower-friendly bankruptcy court). Consider the timing described in Figure 4.7.

The project, if financed, yields random and verifiable short-term profit $r\in[0,\bar{r}]$ (with a continuous density and *ex ante* mean $E[r]$). After r is realized and cashed in, the firm either liquidates (sells its assets), yielding some known liquidation value $L>0$, or continues. Note that (the random) r and (the deterministic) L are not subject to moral hazard. If the

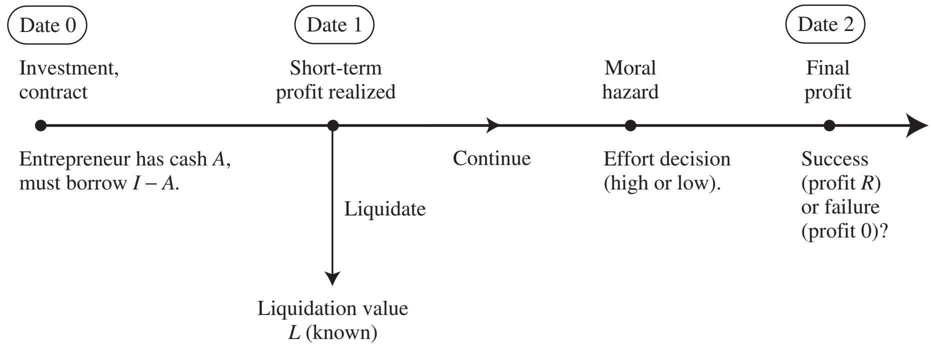

Figure 4.7

firm continues, its prospects improve with r (so r is "good news" about the future). Namely, the probability of success is $p_{\mathrm{H}}(r)$ if the entrepreneur works between dates 1 and 2 and $p_{\mathrm{L}}(r)$ if the entrepreneur shirks. Assume that $p'_{\mathrm{H}} > 0$, $p'_{\mathrm{L}} > 0$, and

$$p_{\mathrm{H}}(r) - p_{\mathrm{L}}(r) \equiv \Delta p$$

is independent of r (so shirking reduces the probability of success by a fixed amount independent of prospects). As usual, one will want to induce the entrepreneur to work if continuation obtains. It is convenient to use the notation

$$\rho_1(r) \equiv p_{\mathrm{H}}(r)R \quad \text{and} \quad \rho_0(r) \equiv p_{\mathrm{H}}(r)\left[R - \frac{B}{\Delta p}\right].$$

Investors are competitive and demand an expected rate of return equal to 0. Assume

$$\rho_1(r) > L \quad \text{for all } r \tag{1}$$

and

$$E[r] + L > I - A > E[r + \rho_0(r)]. \tag{2}$$

(i) Argue informally that, in the optimal contract for the borrower, the short-term profit and the liquidation value (if the firm is liquidated) ought to be given to investors.

Argue that, in the case of continuation, $R_{\mathrm{b}} = B/\Delta p$. (If you are unable to show why, take this fact for granted in the rest of the question.)

Interpret conditions (1) and (2).

(ii) Write the borrower's optimization program.

Assume (without loss of generality) that the firm continues if and only if $r \geqslant r^*$ for some $r^* \in (0, r)$. Exhibit the equation defining r^*.

(iii) Argue that this optimal contract can be implemented using, inter alia, a short-term debt contract at level $d = r^*$. Interpret "liquidation" as a "bankruptcy."

How does short-term debt vary with the borrower's initial equity? Explain.

(iv) Suppose that, when the decision to liquidate is taken, the firm must go to a bankruptcy court. The judge mechanically splits the bankruptcy proceeds L equally between investors and the borrower.

Define $\hat{r}$ by

$$\rho_0(\hat{r}) \equiv \tfrac{1}{2}L.$$

Assume first that

$$r^* > \hat{r}$$

(where r^* is the value found in question (ii)).

Show that the borrower-friendly court actually prevents the borrower from having access to financing. (Note: a diagram may help.)

(v) Continuing on question (iv), show that when

$$r^* < \hat{r},$$

the borrower-friendly court either prevents financing or increases the probability of bankruptcy, and in all cases hurts the borrower and not the lenders.

Exercise 4.10 (benefits from diversification with variable-investment projects). An entrepreneur has two variable-investment projects $i \in \{1, 2\}$. Each is described as in Section 3.4. (For investment level I^i, project i yields RI^i in the case of success and 0 in the case of failure. The probability of success is p_{H} if the entrepreneur behaves (and thereby gets no private benefit) and $p_{\mathrm{L}} = p_{\mathrm{H}} - \Delta p$ if she misbehaves (and then obtains private benefit BI^i). Universal risk neutrality prevails and the entrepreneur is protected

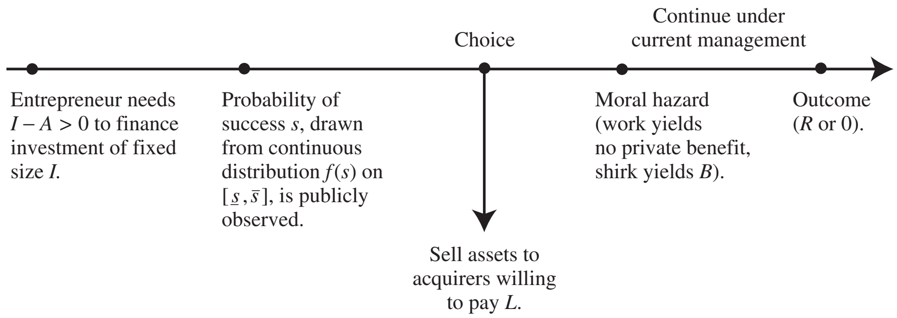

Figure 4.8

by limited liability.) The two projects are *independent* (not correlated). The entrepreneur starts with total wealth A. Assume

$$\rho_1 \equiv p_{\mathrm{H}} R > 1 > \rho_0 \equiv p_{\mathrm{H}}\left(R - \frac{B}{\Delta p}\right)$$

and

$$\rho_0' \equiv p_{\mathrm{H}}\left(R - \frac{p_{\mathrm{H}}}{p_{\mathrm{H}} + p_{\mathrm{L}}}\frac{B}{\Delta p}\right) < 1.$$

(i) First, consider project finance (each project is financed on a stand-alone basis). Compute the borrower's utility. Is there any benefit from having access to two projects rather than one?

(ii) Compute the borrower's utility under cross-pledging.

Exercise 4.11 (optimal sale policy). Consider the timing in Figure 4.8.

The probability of success s is not known initially and is learned publicly after the investment is sunk. If the assets are not sold, the probability of success is s if the entrepreneur works and $s - \Delta p$ if she shirks (in which case she gets private benefit B). Assume that the (state-contingent) decision to sell the firm to an acquirer can be contracted upon *ex ante*. It is optimal to keep the entrepreneur (not sell) if and only if $s \geqslant s^*$ for some threshold s^*. (Assume in the following that s has a wide enough support and that there are no corner solutions. Further assume that, conditional on not liquidating, it is optimal to induce the entrepreneur to exert effort. If you want to show off, you may derive a sufficient condition for this to be the case.) As is usual, everyone is risk neutral, the entrepreneur is protected by limited liability, and the market rate of interest is 0.

(i) Suppose that the entrepreneur's reward in the case of success (and, of course, continuation) is $R_{\mathrm{b}} = B/\Delta p$. Assuming that the financing constraint is binding, write the NPV and the investors' break-even constraint and show that

$$s^* = \frac{(1+\mu)L}{R + \mu(R - B/\Delta p)}$$

for some $\mu > 0$. Explain the economic tradeoff.

(ii) Endogenize $R_{\mathrm{b}}(s)$ assuming that effort is to be encouraged and show that indeed $R_{\mathrm{b}}(s) = B/\Delta p$ for all s. What is the intuition for this "minimum incentive result"?

(iii) Suppose now that s can take only two values, s_1 and s_2, with $s_2 > s_1$ and

$$s_2\left(R - \frac{B}{\Delta p}\right) > \max(L, I - A).$$

Introduce a first-stage moral hazard (just after the investment is sunk). The entrepreneur chooses between taking a private benefit B_0, in which case $s = s_1$ for certain, and taking no private benefit, in which case $s = s_2$ for certain. Assume that financing is infeasible if the contract induces the entrepreneur to misbehave at either stage. What is the optimal contract? Is financing feasible? Discuss the issue of contract renegotiation.

Exercise 4.12 (conflict of interest and division of labor). Consider the timing in Figure 4.9.

The entrepreneur (who is protected by limited liability) is assigned two simultaneous tasks (the moral-hazard problem is bidimensional):

- The entrepreneur chooses between probabilities of success p_{H} (and then receives no private benefit) and p_{L} (in which case she receives private benefit B).
- The entrepreneur is in charge of overseeing that the asset remains attractive to external buyers

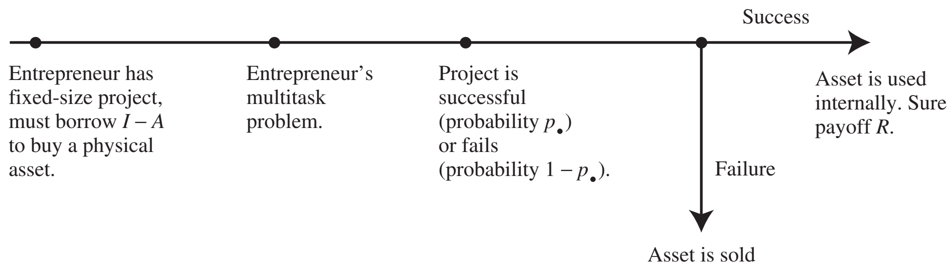

Figure 4.9

in the case where the project fails and the asset is thus not used internally. At private cost c, the entrepreneur maintains the resale value at level L. The resale value is 0 if the entrepreneur does not incur cost c. The resale value is observed by the investors if and only if the project fails.

Let R_{b} denote the entrepreneur's reward if the project is successful (by assumption, this reward is not contingent on the maintenance performance); $\hat{R}_{\mathrm{b}}$ is the entrepreneur's reward if the project fails and the asset is sold at price L; last, the entrepreneur (optimally) receives nothing if the project fails and the asset is worth nothing to external buyers.

The entrepreneur and the investors are risk neutral and the market rate of interest is 0. Assume that to enable financing the contract must induce good behavior in the two moral-hazard dimensions.

(i) Write the three incentive compatibility constraints; show that the constraint that the entrepreneur does not want to choose p_{L} and not maintain the asset is not binding.

(ii) Compute the nonpledgeable income. What is the minimum level of A such that the entrepreneur can obtain financing?

(iii) Suppose now that the maintenance task can be delegated to another agent. The latter is also risk neutral and protected by limited liability. Show that the pledgeable income increases and so financing is eased.

Exercise 4.13 (group lending). Consider the group lending model with altruism in the supplementary section, but assume that the projects are perfectly correlated rather than independent. What is the necessary and sufficient condition for the borrowers to have access to credit?

Exercise 4.14 (diversification and correlation). This exercise studies how necessary and sufficient conditions for the financing of *two projects* undertaken by the same entrepreneur vary with the projects' correlation. The two projects are identical, taken on a stand-alone basis. A project involves a fixed investment cost I and yields profit R with probability p and 0 with probability $1-p$, where the probability of success p is chosen by the entrepreneur for each project: p_{H} (no private benefit) or $p_{\mathrm{L}} = p_{\mathrm{H}} - \Delta p$ (private benefit B).

The entrepreneur has wealth $2A$, is risk neutral, and is protected by limited liability. The investors are risk neutral and demand rate of return equal to 0.

In the following questions, assume that, conditional on financing, the entrepreneur receives R_k when $k \in \{0, 1, 2\}$ projects succeed, and that $R_0 = R_1 = 0$ (this involves no loss of generality).

(i) *Independent projects.* Suppose that the projects are uncorrelated. Show that the entrepreneur can get financing provided that

$$p_{\mathrm{H}}\left[R - \left(\frac{p_{\mathrm{H}}}{p_{\mathrm{H}} + p_{\mathrm{L}}}\right)\frac{B}{\Delta p}\right] \geqslant I - A.$$

(ii) *Perfectly correlated projects.* Suppose that the shocks affecting the two projects are identical. (The following may, or may not, help in understanding the stochastic structure. One can think for a given project of an underlying random variable ω uniformly distributed in $[0, 1]$. If $\omega < p_{\mathrm{L}}$, the project succeeds regardless of the entrepreneur's effort. If $\omega > p_{\mathrm{H}}$, the project fails regardless of her effort. If $p_{\mathrm{L}} < \omega < p_{\mathrm{H}}$, the project succeeds if and only if she behaves. In the case of independent projects, ω_1 and ω_2 are independent and identically distributed (i.i.d.). For perfectly correlated projects, $\omega_1 = \omega_2$.) Show that the two projects can be financed if and

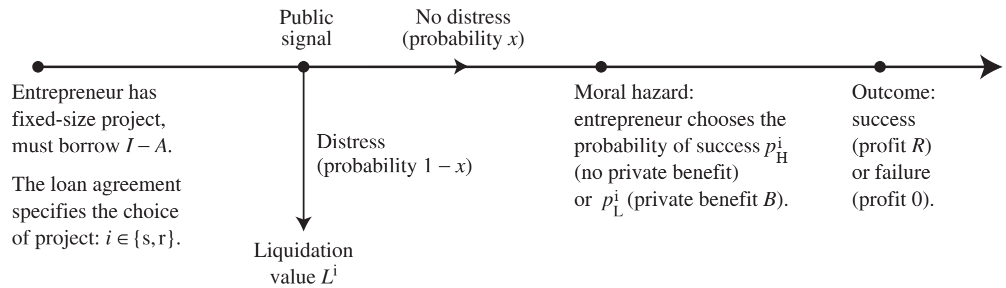

Figure 4.10

only if

$$p_H\left(R - \frac{B}{\Delta p}\right) \geqslant I - A.$$

(iii) *Imperfectly correlated projects.* Suppose that with probability x the projects will be perfectly correlated, and with probability $1 - x$ they will be independent (so $x = 0$ in question (i) and $x = 1$ in question (ii)). Derive the financing condition. What value of x would the entrepreneur choose if she were free to pick the extent of correlation between the projects: (a) before the projects are financed, in an observable way; (b) after the projects are financed?

Exercise 4.15 (credit rationing and bias towards less risky projects). This exercise shows that a shortage of cash on hand creates a bias toward less risky projects. the same proposition in the context of a tradeoff between collateral value and profitability. The timing, depicted in Figure 4.10, is similar to that studied in Section 4.3.

The entrepreneur must finance a fixed-size project costing I, and has initial net worth $A < I$. If investors consent to funding the project, investors and entrepreneurs agree, as part of the loan agreement, on which variant, $i = \mathrm{s}$ (safe) or r (risky) is selected. A public signal accrues at an intermediate stage. With probability x (independent of the project specification), the firm experiences no distress and continues. The production is then subject to moral hazard. The entrepreneur can behave (yielding no private benefit and probability of success p_H^i) or misbehave (yielding a private benefit B and probability of success p_L^i); success generates profit R. One will assume that

$$p_H^s - p_L^s = p_H^r - p_L^r \equiv \Delta p > 0.$$

With probability $1 - x$, the firm's asset must be resold, at price L^i with $L^i < p_H^i R$.

We assume that two specifications are equally profitable but the risky project yields a higher long-term profit but a smaller liquidation value (for example, it may correspond to an off-the-beaten-track technology that creates more differentiation from competitors, but also generates little interest in the asset resale market):

$$L^s > L^r$$

and

$$(1 - x)L^s + x p_H^s R = (1 - x)L^r + x p_H^r R.$$

The entrepreneur is risk neutral and protected by limited liability, and the investors are risk neutral and demand a rate of return equal to 0.

(i) Show that there exists $\bar{A}$ such that for $A > \bar{A}$, the entrepreneur is indifferent between the two specifications, while for $A < \bar{A}$, she strictly prefers offering the safe one to investors.

(ii) What happens if the choice of specification is not contractible and is to the discretion of the entrepreneur just after the investment is sunk?

Exercise 4.16 (fire sale externalities and total surplus-enhancing cartelizations). This exercise endogenizes the resale price P in the redeployability model of Section 4.3.1 (but with variable investment). The timing is recapped in Figure 4.11.

The model is the variable-investment model, with a mass 1 of identical entrepreneurs. The representative entrepreneur and her project of endogenous size I are as in Section 4.3.1. In particular, with probability x the project is viable, and with probability $1-x$ the project is unproductive. The assets are then resold to "third parties" at price P. The shocks faced by individual firms (whether productive or not) are

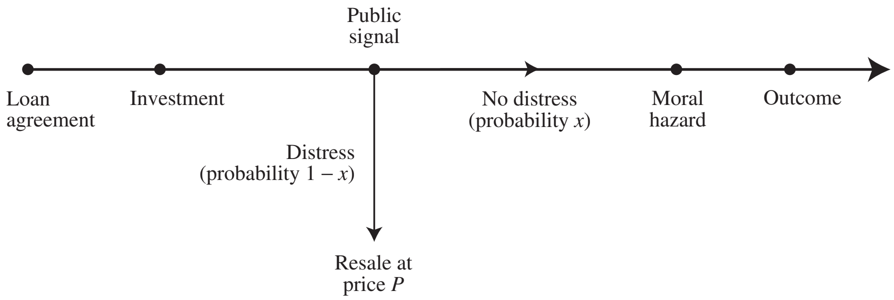

Figure 4.11

independent, and so in equilibrium a fraction x of firms remain productive, while a volume of assets $J = (1-x)I$ (where I is the representative entrepreneur's investment) has become unproductive under their current ownership.

The third parties (the buyers) have demand function $J = D(P)$, inverse demand function $P = P(J)$, gross surplus function $S(J)$ with $S'(J) = P$, net surplus function $S^{\mathrm{n}}(P) = S(J(P)) - PD(P)$ with $(S^{\mathrm{n}})' = -J$. Assume $P(\infty) = 0$ and $1 > x\rho_0$.

(i) Compute the representative entrepreneur's borrowing capacity and NPV.

(ii) Suppose next that the entrepreneurs *ex ante* form a cartel and jointly agree that they will not sell more than a fraction $z < 1$ of their assets when in distress.

Show that investment and NPV increase when asset sales are restricted if and only if the elasticity of demand is greater than 1:

$$-\frac{P'J}{P} > 1.$$

Check that this condition is not inconsistent with the stability of the equilibrium (the competitive equilibrium is stable if the mapping from aggregate investment I to individual investment i has slope greater than -1).

(iii) Show that total (buyers' and firms') surplus can increase when z is set below 1.

Exercise 4.17 (loan size and collateral requirements). An entrepreneur with limited wealth A finances a variable-investment project. A project of size $I \in \mathbb{R}$ if successful yields $R(I)$, where $R(0) = 0$, $R' > 0$, $R'' < 0$, $R'(0) = \infty$, $R'(\infty) = 0$. The probability of success is p_{H} if the entrepreneur behaves (she then receives no private benefit) and $p_{\mathrm{L}} = p_{\mathrm{H}} - \Delta p$ if she misbehaves (she then receives private benefit BI).

The entrepreneur can pledge an arbitrary amount of collateral with cost $C \geqslant 0$ to the entrepreneur and value $\phi(C)$ for the investors with $\phi(0) = 0$, $\phi' > 0$, $\phi'' < 0$, $\phi'(0) = 1$, $\phi'(\infty) = 0$.

The entrepreneur is risk neutral and protected by limited liability and the investors are competitive, risk neutral, and demand a rate of return equal to 0.

Assume that the first-best policy does not yield enough pledgeable income. (This first-best policy is $C^* = 0$ and I^* given by $p_{\mathrm{H}}R'(I^*) = 1$. Thus, the assumption is $p_{\mathrm{H}}[R(I^*) - BI^*/\Delta p] < I^* - A$.)

Assume that the entrepreneur pledges collateral only in the case of failure (on this, see Section 4.3.5), and that the investors' breakeven constraint is binding. Show that as A decreases or the agency cost (as measured by B or, keeping p_{H} constant, $p_{\mathrm{H}}/\Delta p$) increases, the optimal investment size decreases and the optimal collateral increases.

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