Financing and Taxing New Firms under Asymmetric Information

by

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Abstract

This paper uses a sequence of models to study the efficiency of credit market equilibria, and the scope for welfare-improving policy interventions, when financial intermediaries cannot observe the riskiness or returns of potential investment projects by new firms. It is first shown that when only loan financing is available there is systematic tendency towards over-investment in high-return, high-risk projects and under-investment in low-return, low-risk projects relative to the social optimum (this encompassing the well-known results of Stiglitz and Weiss (1981) and de Meza and Webb (1987) as special cases). The ambiguity is mitigated, however, if firms have access to equity finance: there is then (under reasonable conditions) unambiguously over-investment. Policy implications are developed, and the results extended to allow for screening and signaling equilibria.

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1. Introduction

The appropriate tax treatment of income from investment and saving has long been a central concern in public finance, focusing in particular on whether or not capital income ought to be taxed (or subsidized) at all. This strand of literature, from Chamley (1986) on, almost invariably assumes that capital markets function efficiently.[1] Over recent years, the public finance literature has thus become virtually disjoint from the finance literature, which has instead stressed and explored the possibility of inefficient outcomes in financial markets as a consequence of informational asymmetries.[2] The purpose of this paper is to go some way towards closing this gap, developing a sequence of results on financial market inefficiencies in the search for practicable guidance for proper policy formation. Our focus, following Stiglitz and Weiss (1981) and de Meza and Webb (1987), is on investment in new firms. A parallel literature exists on inefficiency in investment in established firms, originating with Myers and Majluf (1984). As it turns out, our results are in sharp contrast to their's, as we shall indicate below.

A key insight from Stiglitz and Weiss (1981) and de Meza and Webb (1987) is that when intermediaries are unable to distinguish between high- and low-quality new investment projects, they will make an inefficient volume of loans. This may create the possibility of welfare-improving interventions even by a government that is no better informed than the intermediaries themselves. However, whether too many or too few loans will be extended depends upon the distribution of project characteristics within the pool. The literature has focused on two special cases, reflecting different assumptions on the distribution of available projects, that yield opposing outcomes and policy implications. In one, due to Stiglitz and Weiss (1981), too few projects of any given expected return will be undertaken, leading to a policy prescription of a subsidy on loans. In the other, due to de Meza and Webb (1987), too many projects of a given ex post return will be funded, calling for a tax on loans.[3] One is left with no clear policy implications of the effects of adverse selection in credit markets.

The first step in addressing this ambiguity is to understand it better. The paper thus

[1] See Boadway and Keen (2003) for a review.

[2] See Stein (2003) for a survey of this literature.

[3] Furthermore, the Stiglitz-Weiss case can lead to credit rationing (excess demand for loans) in equilibrium, whereas in the de Meza-Webb case credit rationing cannot arise. And, de Meza and Webb argue, if equity contracts were available as an alternative to debt contracts, they would be used in the Stiglitz-Weiss case, but not in their own. Mankiw (1986) has also considered credit market breakdown in a context similar to ours in which project returns can take a general form. He points out that loan markets may 'collapse' in the sense that there may be no equilibrium in which loans are made—an extreme case of credit rationing.

starts (after some preliminaries in Section 2) by providing a general treatment of the potential inefficiencies that arise in informationally constrained debt markets: 'general' here meaning that, unlike the de Meza-Webb and Stiglitz-Weiss cases, no particular assumption is made on the distribution of project types (characterized by different combinations of risk and return). Using a simple diagrammatic device, we establish the nature of the general biases created by informational problems. Naturally, the policy implications must remain unclear since the two cases on which the literature has focused are encompassed as special cases, but understanding the nature of the inefficiencies clarifies the essential policy problem. This debt-only case sets the scene for subsequent sections, in which we consider alternative financial possibilities: when only equity finance is available (Section 4) and when entrepreneurs can choose between debt and equity (Section 5). In these cases, it will be seen, the ambiguity as to the optimal direction of policy is mitigated. Section 6 considers some extensions to this sequence of models, introducing screening and signaling mechanisms that enhance the information available to intermediaries. Section 7 summarizes and concludes.

2. The Basic Model

The models we use have a number of common features, broadly standard in the established literature. There is a continuum of potential entrepreneurs, each with a single project for which finance is needed. All projects require a given amount of capital K, which is the only input. A project's return depends upon which of two states of nature occurs: the 'good' state occurs with probability p and yields a return R, where $0 \leq p \leq 1$, $0 \leq R < \infty$; the 'bad' state occurs with probability $1-p$ and, for simplicity, the project return is then zero. Each project (and entrepreneur) is thus characterized by a particular $\{p, R\}$ combination. The returns of distinct projects are independently distributed.

The distribution of project returns among entrepreneurs is described by the joint distribution function $G(p, R)$ and associated density function $g(p, R)$. This distribution can take arbitrary forms. In particular, there may be ranges where the density is zero, $g(p, R) = 0$. The characteristics of individual projects are private information to the entrepreneur associated with each project, but the distribution $G(p, R)$ is known both to the financial intermediaries and to the government. Thus, the government is no better informed than intermediaries.

All entrepreneurs have the same initial wealth $W \geq 0$, and all have the same alternative income prospects y that they forgo if they undertake the project. They therefore all require the same amount of external finance $K - W = B$ to undertake their projects, which they may seek to obtain from financial intermediaries. Successive sections deal with different possibilities in terms of the kind of finance available. Intermediaries, in turn, obtain their finance at a rate of return (or deposit rate) ρ, which is taken as fixed by each intermediary but may be variable for the capital market as a whole. All agents in the economy—entrepreneurs, financial intermediaries and the government—are risk-neutral. Intermediaries are fully competitive, and so earn zero expected profits in equilibrium. Stiglitz and Weiss (1981) showed that in the kinds of models we are considering, credit rationing is a possibility—indeed that was the main focus of their paper. That is, banks may be unwilling to increase the interest rate in the face of an excess demand for loans if high-quality projects are deterred from borrowing. Since credit rationing is not our interest, however, we assume that it does not in fact occur.

It is assumed that project returns are not freely observable, but that intermediaries can learn a project's ex post return perfectly by incurring a fixed monitoring cost of $c \geq 0$ per project monitored once the state of nature is revealed.[4] With debt contracts, monitoring will occur if and only if firms declare bankruptcy since in the absence of bankruptcy the intermediary's return is independent of the project return R. Indeed, the existence of costly verification can itself be the rationale for debt financing (Williamson, 1987).

3. Debt Finance Only

Equilibrium and Inefficiency

We begin with the case in which debt is the only form of external finance available. To avoid issues of collateral, taken up later, it is assumed in this section that entrepreneurs have no initial wealth ($W = 0$). To undertake their projects, they therefore require an amount of loan finance $B = K$, which they can borrow at the interest rate r from an intermediary (a 'bank'). The net expected profit of an entrepreneur, given r, is:

$$\pi(p, R, r) = p(R - (1 + r)B) - y \tag{1}$$

This is increasing in p for funded projects (since then $R > (1 + r)B$) and in R, and decreasing in r. Given r, there will be a set of marginal entrepreneurs whose projects satisfy $\pi(p, R, r) = 0$. This equation can be depicted as a *zero-profit curve* for the marginal entrepreneurs in $(p, R)-$space (shown in Figure 1), with slope and curvature of:

$$\left.\frac{dR}{dp}\right|_{\pi=0} = -\frac{R - (1 + r)B}{p} < 0, \qquad \left.\frac{d^2R}{dp^2}\right|_{\pi=0} = -\frac{1}{p}\left.\frac{dR}{dp}\right|_{\pi=0} + \frac{R - (1 + r)B}{p^2} > 0 \tag{2}$$

where the signs follow from the fact that $\pi(p, R, r) = 0$ implies $R > (1 + r)B$. All entrepreneurs whose projects have combinations of p and R to the northeast of the zero-profit curve will demand a loan, while those to the southwest will not. Note that since π is decreasing in r, an increase in r will cause the zero-profit curve to shift outwards.

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[4] In a more general analysis, the possibility of imperfect monitoring could be considered. This would affect the nature of contracts offered to firms, which must be generous enough to preclude false declarations of bankruptcy. As well, ex ante monitoring might be used to improve banks information of project quality (Boadway and Sato, 1999).

Entrepreneurs will be unable to repay their loans in the bad states, so will go bankrupt and, since returns cannot be observed, will have to be monitored ex post at a cost. Since the government has no better information than the banks, these ex post monitoring costs will be socially necessary expenditures. Given that, the net social benefit of undertaking a project with characteristics $\{p, R\}$ is:

$$S(p,R) = pR - (1-p)c - (1+\rho)B - y \tag{3}$$

This is increasing in both p and R, and is independent of the interest rate r. A *zero-benefit curve* for marginally socially profitable projects is defined by $S(p,R) = 0$, also shown in Figure 1, with slope and curvature:

$$\left.\frac{dR}{dp}\right|_{S=0} = -\frac{R+c}{p} < 0, \qquad \left.\frac{d^2R}{dp^2}\right|_{S=0} = -\frac{1}{p}\left.\frac{dR}{dp}\right|_{S=0} + \frac{R+c}{p^2} > 0 \tag{4}$$

Thus, the zero-benefit curve also slopes downward and is convex to the origin. All projects to its northeast are socially beneficial, all to the southwest are not.

Comparing the slopes of the two curves, one finds:

$$\left.\frac{dR}{dp}\right|_{S=0} = -\frac{R+c}{p} < -\frac{R-(1+r)B}{p} = \left.\frac{dR}{dp}\right|_{\pi=0}$$

so that the zero-benefit curve is steeper than the zero-profit curve. Intuitively, since entrepreneurs only bear the cost of finance in the event of success while society bears it in either state, the increment in R needed to compensate them for a reduced probability of success (and hence increased chance of incurring the monitoring costs) is less than is required from the wider social perspective. The intersection point between the two curves is found by subtracting the zero-benefit expression from the zero-profit expression to give:

$$p^* = \frac{(1+\rho)B + c}{(1+r)B + c} \tag{5}$$

Note that the value of p^* will decrease with an increase in r: the zero-profit curve shifts outwards while the zero-benefit curve is unaffected.

The final element in characterizing equilibrium is the determination of the interest rate charged by the banks, r. This follows from the zero-expected-profit condition applying to the (identical) competitive banks:[5]

$$\Pi = \overline{p}(1+r)B - (1-\overline{p})c - (1+\rho)B = 0 \tag{6}$$

[5] We assume that banks do not incur any real costs of operation, as is common in the literature. Adding bank operating costs would have no substantive effect on the analysis.

where $\overline{p}$ is the expected probability of success among all projects being funded by the banks. Rearranging this zero-profit condition and using (5) gives:

$$\overline{p} = \frac{(1+\rho)B + c}{(1+r)B + c} = p^* \tag{5'}$$

Thus, the equilibrium interest rate is such that the expected probability of success of all accepted projects $\overline{p}$ is equal to the value of p at which the zero-benefit and zero-profit curves intersect (the zero-profit curve shifting with a change in r until this is the case). The intuition is simply that the difference between private profit to the entrepreneur π and social benefit S is the payment to the bank: when the former two are both zero, so too are bank profits. This equality between p^* and $\overline{p}$ proves useful in what follows.

Credit market equilibrium is depicted in Figure 1 for an arbitrary distribution $G(p, R)$, whose support is shown as the irregular-shaped enclosed region. Projects fall, in equilibrium, into four categories. The outcomes with respect to those in regions A and B are fully efficient: the former are socially desirable projects that are in fact undertaken; the latter are undesirable projects that are not undertaken. The other regions are ones of inefficiency, and, moreover, it can be seen that the inefficiencies take particular forms. Region C comprises (loosely speaking), low-p high-R projects that should not be undertaken but are: these are projects for which the return in the good state is enough to make the investment privately profitable but not high enough to compensate society for the relatively high expected monitoring costs. Region D, on the other hand, consists of high-p low-R projects that should be undertaken but are not: in these cases the relatively low return leaves the investor too little in the good state, after payment of interest, but is enough from the social perspective given relatively low expected monitoring costs. Note, however, that monitoring costs are not responsible for these qualitative results. Even if monitoring costs were zero (as implicitly assumed by Stiglitz and Weiss, 1981 and de Meza and Webb, 1987), the outcomes depicted in Figure 1 would apply.

The nature of the potential inefficiency is thus, in general, somewhat complex. It is not simply a matter of aggregate over- or under-investment. Rather it takes the form of a systematic tendency towards over-investment in low-p high-R projects, and under-investment in high-p low-R ones. The reason for this is simply that increases in p are of relatively more value socially than they are to entrepreneurs, both because a share of the proceeds of successful projects accrues to banks and because entrepreneurs do not bear the full costs—but only a part (through the interest they pay if successful)—of the monitoring costs associated with project failure.

Two special cases that have figured prominently in the literature are of particular interest. One, considered by de Meza and Webb (1987) and elaborated on more recently by de Meza (2002), is that in which the return to each project if it succeeds is common knowledge.

Intermediaries are then able to classify projects by R. Without loss of generality, we can then suppose that R takes only one value: the same analysis would apply for each set of projects with a common R (with the banks also charging a different r in each such case). In this case—illustrated in Figure 2—the support of $G(p, R)$ lies on a horizontal line that intersects the zero-profit locus at some point $\tilde{p}$ to the left of p^*.[6] Region D can then readily seen to be empty, so that the only inefficiency is of the kind in region C: over-investment in low-p high-R projects. Unambiguously too many projects are accepted.[7]

The second leading special case is that in which intermediaries can identify all projects with the same expected return pR. This is the case considered by Stiglitz and Weiss (1981), although—as will soon be seen—it is important to note that they also assume that there are no monitoring costs. Indeed the equilibrium outcomes and policy implications in this case are not as straightforward as the existing literature seems to imply. To see this, we can as before focus without loss of generality on a single set of indistinguishable projects, those for which $pR = k$, for some common k. The support of $G(p, R)$ then lies along a rectangular hyperbola whose slope (denoted by $dR/dp|_{SW}$) is readily shown to be such that, for $c > 0$:

$$\left.\frac{dR}{dp}\right|_{S=0} < \left.\frac{dR}{dp}\right|_{SW} < \left.\frac{dR}{dp}\right|_{\pi=0} < 0 \tag{8}$$

Thus the slope of the locus of projects available is between those of the zero-profit and the zero-benefit loci (with its exact position depending on the value of k). Figure 3 illustrates.[8]

Region B (in the language of the general case in Figure 1) can be seen to be empty in this case: if any projects are socially desirable then all are, since they have the same expected return. More significant, however, is that the two regions of inefficiency, C and D, are typically then both non-empty: there is both over-investment in low-p projects (those with $p < p^o$) and under-investment in high-p projects (those with $p > \tilde{p}$).

This ambiguity stands in contrast with the original and much-cited finding of Stiglitz-Weiss (1981) that there is under-investment in equilibrium. The starkness of that result,

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[6] The intersection cannot be to the right of p^*, since then all accepted projects would have a probability of success in excess of the average $\overline{p}$, a contradiction.

[7] This over-investment result can be shown more formally by adding the marginal entrepreneur's zero-net-profit condition and the banks' zero-expected-profit condition and rearranging to find that the social profitability of the marginal project, $S(\tilde{p})$, is:

$$S(\tilde{p}) = \tilde{p}R - (1 - \tilde{p})c - (1 + \rho)B - y = (\tilde{p} - \overline{p})((1 + r)B - c) \tag{7}$$

Since $\overline{p} > \tilde{p}$ in this case, the marginal project has negative social benefits; and since social benefits are increasing in p, there is too much entry of low-p projects.

[8] We assume here that k is such that $\tilde{p}$ is in the interior.

however, reflects their implicit assumption that monitoring is costless. With $c = 0$, it is readily verified that the slope of the locus of available projects coincides with that of the zero-benefit locus. In this case, region C—that of over-investment in low-p projects—disappears, and there is indeed unambiguously too little investment.

Policy

With the market outcome generally inefficient, the question arises as to whether there exist informationally feasible, welfare-improving policy interventions.

The first-best can be achieved by imposing a tax $T(p,R)$ on each successful project such that, for all possible pairs $\{p,R\}$, private and social profitability coincide. This is readily shown to require that

$$T(p,R) = T(p) = [(1-p)c + (1+\rho - p(1+r))B]/p$$

with the fully corrective tax thus being independent of R, and with $T'(p) < 0$ and $T(\overline{p}) = 0$. Thus, as one would expect from the analysis above, the optimal corrective policy involves subsidizing projects with higher than average probability of success and taxing those with lower than average. The difficulty, of course, is that p is typically not observable: indeed if it were then it is easily seen, using the diagrammatic approach above, that there would be no inefficiency to correct.

A more plausible informational assumption is that the government can observe whether a project succeeds or fails, and so can impose differential taxes or subsidies in the two cases. Denoting by τ_1 a common tax imposed on all successful firms and τ_2 a common tax on all unsuccessful, after-tax expected profits become, using (1):

$$\pi(p,R,r) = p(R - (1+r)B - \tau_1) - (1-p)\tau_2 - y$$

which is identical to social profitability, for all p and R, if and only if:

$$\tau_1 = (\rho - r)B \qquad \text{and} \qquad \tau_2 = c + (1+\rho)B$$

Successful firms would thus receive an interest subsidy to ensure that they borrow at the true social cost of funds, while unsuccessful would pay an amount equal to the social costs that their failure imposes. There is again an insurmountable difficulty, however: if unsuccessful firms had the resources to pay the tax τ_2 they would not have needed outside financing in the first place. Therefore, this informationally parsimonious policy is not feasible, and the ability to differentiate between successful and unsuccessful projects does not enable the first-best to be achieved Nor can such differentiation be used even to bring about a sure improvement over the no-intervention outcome: simply implementing the subsidy to successful projects, in particular, may worsen matters in so far as the additional encouragement to projects that are socially desirable but otherwise not undertaken is more than outweighed by the additional encouragement to socially undesirable projects.

A more promising policy aproach involves the standard income tax system in which taxpayers self-report their ex post incomes, subject to an audit and penalty system to deter tax evaders. Under such a system, the government could in principle correct the credit-market inefficiency if entrepreneurs reported R truthfully. From (7), the distortion involved with the marginal project for any R is proportional to $\tilde{p} - \overline{p}$. Since $\tilde{p} - \overline{p}$ is negative for low values of R, positive for high values, and rises with R, a appropriately progressive tax on R would be efficient.

The least informationally demanding policy is a uniform tax or subsidy to all accepted projects (the precise form of this—a tax on interest paid to or by banks, on project returns or as a fixed sum—being immaterial in this model). Clearly whether it is a tax or a subsidy that increases welfare at the margin depends on the relative weights of the density $g(p, r)$ along the zero-profit locus in the regions of over- and under-investment (C and D respectively), which is likely to be hard to know. Only in special cases in which there is unambiguously over- or under-investment is the optimal direction of policy clear-cut. In the de Meza-Webb case, for instance, a small tax is certain to improve welfare by eliminating some socially undesirable projects: diagrammatically, the zero-profit locus shifts outward in Figure 2. Conversely, a subsidy is optimal in the Stiglitz-Weiss case with $c = 0$. Even in these cases, however, the fully optimal policy is quite complex. In Figure 2, for instance, the first-best requires shifting the zero-profit locus until its intersection with the horizontal line at $\overline{R}$ is at p^*—which requires a different tax for each class of projects distinguished by R.

4. Equity Finance Only

Suppose now that intermediaries will provide finance to entrepreneurs only in exchange for a share of the project returns. Let σ denote the share of a project's returns going to the entrepreneur; the remaining $(1 - \sigma)$ goes to the intermediary. In this case, all projects must be monitored since returns need to be verified in both good and bad states.

Pooled Outcome

Assume initially that all funded projects are pooled and obtain the same share σ. The expected net profits of entrepreneurs are:

$$\pi(p, R, \sigma) = \sigma pR - y$$

For the marginal entrepreneur $\pi(p, R, \sigma) = 0 = \sigma \widetilde{pR} - y$, so the expected returns on marginal projects are:

$$\widetilde{pR} = \frac{y}{\sigma} \tag{9}$$

Since expected profits are increasing in the expected return, all projects with $pR \geq \widetilde{pR}$ apply for financing.

The zero-benefit locus in $(R, p)-$space is now defined by $S(p, R) = pR - c - (1+\rho)B - y = 0$, which differs from (3) in that all projects are now monitored. Along this locus, expected returns are constant and denoted $(pR)^o$, where:

$$(pR)^o = (1 + \rho)B + c + y \tag{10}$$

All projects with $pR \geq (pR)^o$ should be undertaken from a social point of view.

The zero-profit and the zero-benefit loci are both rectangular hyperbolae, defined by (9) and (10), and so do not intersect (leaving aside the case in which they coincide, which as we shall see cannot occur). Whether there are too few or too many projects undertaken then simply depends on which locus lies furthest northeast, which turns on which of $\widetilde{pR}$ and $(pR)^o$ is the larger. To make this comparison, first use the intermediaries' zero-expected-profit condition to obtain the equilibrium share σ offered by intermediaries in return for providing finance B:

$$(1 - \sigma)\overline{pR} - (1 + \rho)B - c = 0 \implies \sigma = \frac{\overline{pR} - (1 + \rho)B - c}{\overline{pR}} \tag{11}$$

where $\overline{pR}(> \widetilde{pR})$ is the average expected return of all projects being funded. Substituting this into the zero-profit condition (9) and rearranging gives:

$$\widetilde{pR} = y + \frac{\widetilde{pR}}{\overline{pR}}((1 + \rho)B + c) \;<\; y + (1 + \rho)B + c = (pR)^o \tag{12}$$

Thus the zero-profit curve lies uniformly inside the zero-benefit curve, and hence too many projects are undertaken in the market equilibrium. In terms of the diagrammatic apparatus above, region D is in this case empty. This unambiguous conclusion—note in particular that it does not require any restriction on the distribution of projects $G(p, R)$—stands in sharp contrast to the ambiguity seen above for the case in which only debt finance is available. The policy prescription is also clear: welfare would be improved by a small tax—which could again take a variety of forms—on all projects. Fully optimal policy requires imposing a tax that shifts the zero-profit curve inwards until it intersects the zero-benefit curve.

To see why this is, suppose that σ is initially such that the marginal project in (9) yields positive social benefit. Then the intermediary's expected profit on that project is readily seen to be positive, and hence so too are its aggregate expected profits. Any such intermediary could then be undercut by another that offers entrepreneurs a greater share of the ex post return. In this way the share σ is competed down to the point at which all socially desirable projects are accepted and so too, in order to ensure a zero return to banks, are some that are not desirable. When only debt finance is available, in contrast, some socially desirable projects may remain without finance because setting a low enough interest rate r to attract them all may also attract undesirable low-p high-R projects.

Contracts Contingent on Ex Post Returns

In order to implement equity finance, it must be possible to observe R ex post by monitoring all projects. That being so, equity contracts could in principle be made conditional on R.[9] The implications of this are straighforward: all such equity-financed contracts lead to over-investment. To see this, let σ_R be the share of profits going to entrepreneurs whose projects have an ex post return of R. Expected profits for such projects become:

$$\pi(p, R, \sigma_R) = \sigma_R pR - y$$

The marginal project, given R, will satisfy $\sigma_R \tilde{p}_R R - y = 0$, where $\tilde{p}_R$ is the probability of success of the marginal project, given R. Since profits are increasing in p, all projects such that $p \geq \tilde{p}_R$ will be undertaken.

The zero-expected-profit condition for intermediaries is:

$$(1 - \sigma_R)\overline{p}_R R - c - (1 + \rho)B = 0$$

where $\overline{p}_R(> \tilde{p}_R)$ is the average probability of success of all projects funded. Combining the zero-profit condition for the marginal project with the intermediaries' zero-profit condition:

$$S(\tilde{p}_R) = \tilde{p}_R R - (1 - \tilde{p}_R)c - (1 + \rho)B - y = (\tilde{p}_R - \overline{p}_R)(1 - \sigma_R)R \; < \; 0$$

Thus, for any R the marginal project yields negative social benefits. There will be over-investment, leading to a presumption for taxation of new equity-financed investments.

The results of this section stand in sharp contrast with those found by Myers and Majluf (1984) for new investments in existing firms. They showed that managers of existing firms may choose not to undertake some projects financed by new share issues that would otherwise be beneficial to existing shareholder. With imperfect information, potential shareholders will undervalue high-quality projects and may also obtain a share of high-value existing capital at the expense of existing shareholders. There will tend to be under-investment, at least from the point of view of existing shareholders. In contrast, as we have seen, there will be unambiguously over-investment by new firms when information is imperfect.

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[9] There may be an implementation problem with contracts contingent on R since there is no assurance that intermediaries will reveal R truthfully to third parties, such as the courts. We ignore this verifiability problem in this sub-section.

5. Debt or Equity Finance

If returns can be observed ex post, the choice between debt and equity finance should be endogenous. In this section, we assume that competition among financial intermediaries determines which projects are financed by debt and which by equity. Suppose initially, as in Hellmann and Stiglitz (2000),[10] that there are two sorts of financial intermediaries: those that provide debt finance and those that provide equity finance. Both are risk-neutral and competitive, and both provide a common contract to a pool of projects. Note that while ex post monitoring costs c must be incurred in the event of bankruptcy with debt finance, they must be incurred for all outcomes under equity finance (to verify project returns to be shared, R). Entrepreneurs can choose their most preferred form of finance. Those who choose debt pay an interest rate r; those who choose equity obtain a share of revenues σ.

Entrepreneurs' expected net profits under debt and equity finance are given (in obvious notation) by:

$$\pi^D(p,R,r) = p(R-(1+r)B) - y, \qquad \pi^E(p,R,\sigma) = \sigma pR - y \tag{13}$$

As before, define zero-profit curves for debt and equity finance, given r and σ, by $\pi^D(p,R,r) = 0$ and $\pi^E(p,R,\sigma) = 0$. Differentiating along these zero-profit curves, we obtain:

$$\left.\frac{dR}{dp}\right|_{\pi^D=0} = -\frac{R-(1+r)B}{p} \;>\; -\frac{R}{p} = \left.\frac{dR}{dp}\right|_{\pi^E=0}$$

The zero-profit curve for debt is therefore flatter than that for equity, so intersects it from below (assuming, as we do, that the intersection is in the interior). Given r and σ, the intersection point will satisfy $\pi^D(p,R,r) = \pi^E(p,R,\sigma) = 0$, or, using (13):

$$\widehat{R} = \frac{(1+r)B}{1-\sigma} \tag{14}$$

If firms have a choice between forms of finance given r and σ, they will choose debt if:

$$\pi^D(p,R,r) - \pi^E(p,R,\sigma) = p((1-\sigma)R-(1+r)B) > 0 \implies R > \widehat{R}$$

For $R < \widehat{R}$, equity finance will be chosen.

Figure 4 illustrates the projects that will apply for finance of one sort or another, and which type of finance will be preferred. The horizontal line at $\widehat{R} = (1+r)B/(1-\sigma)$ divides the project space into those that would be financed by debt and those by equity. All projects that are above the horizontal line and to the right of the debt zero-profit curve

[10] The focus of Hellmann and Stiglitz (2000) was on credit rationing rather than inefficiency in the number of projects financed. As before, we ignore the possibility of credit rationing.

are financed by debt. All projects that are below the horizontal line and to the right of the zero-profit curve for equity are financed by equity. Those to the southwest of both curves are not financed at all. The intuition is that projects with high R (and low p) take debt finance because all the residual of a good outcome goes to the entrepreneur; conversely, low risk-low return projects take equity finance.

Social net benefits are defined as before, taking account of the fact that with debt finance monitoring is only necessary in the event of bankruptcy. Zero-benefit curves for debt and equity finance are thus defined by:

$$S^D(p,R) = pR - (1-p)c - (1+\rho)B - y = 0$$

$$S^E(p,R) = pR - c - (1+\rho)B - y = S^D(p,R) - pc = 0 \tag{15}$$

The slopes of these two zero-benefit curves are given by:

$$\left.\frac{dR}{dp}\right|_{S^E=0} = -\frac{R}{p} > -\frac{R+c}{p} = \left.\frac{dR}{dp}\right|_{S^D=0}$$

Thus, $S^E(p,R) = 0$ will be a rectangular hyperbola, like the zero-profit locus of entrepreneurs under equity financing. By the same argument as in Section 4, this zero-benefit curve lies outside the zero-profit locus for equity-financed projects. The zero-benefit curve is steeper for debt-financed projects than for equity-financed projects. Moreover, as (15) implies, if monitoring costs c are not too large, the zero-benefit curve $S^D = 0$ will intersect the zero-profit curve $\pi^D = 0$ at $R < \widehat{R}$ as shown in Figure 4.[11] If that is the case, the zero-benefit curve for debt financed projects $S^D = 0$ will lie outside the zero-profit curve $\pi^D = 0$ whenever debt is chosen ($R > \widehat{R}$).

The implication is that, for c not too large, there will be too many projects financed both by debt and equity. Thus, allowing for both debt and equity finance, the ambiguity found earlier for the case in which debt finance is available again disappears, at least for small c. There will too many projects financed by both debt and equity, calling for a tax on the financing of all projects. Of course, the first-best tax rates will differ across projects of different $\{p, R\}$ characteristics, but these cannot be implemented without the government

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[11] More generally, at the intersection point $\pi^D = 0 = S^D$, $R^* = (1+r)B + [(1+r)B + c]y/[(1+\rho)B + c]$. Combining this with expression (14) for $\widehat{R}$, and using (11) to determine σ, we obtain after some manipulation:

$$R^* = \widehat{R}\frac{(pR)^{Eo}}{\overline{pR}^E} + \frac{cy}{(1+\rho)B + c}$$

where $(pR)^{Eo}$ is the expected return along the zero-benefit curve $S^E = 0$ and $\overline{pR}^E$ is expected profits along the zero-profit curve $\pi^E = 0$. Since $(pR)^{Eo} < \overline{pR}^E$, $R^* < \widehat{R}$ if cy is small enough.

having better information about projects than intermediaries. Nevertheless, the direction of the optimal intervention is again clear-cut: a small tax on projects of all types will be welfare-improving.[12]

It should be noted too that there is another kind of inefficiency in this case: recalling (15), and as can be seen from Figure 4, it would be socially preferable if all projects financed by equity were instead financed by debt (because the expected monitoring costs would thereby be reduced). This creates a case for a differentially high tax rate on equity finance: a small tax of this kind would eliminate some socially undesirable projects altogether and cause others to shift from equity to debt finance. Again, reaching the full optimum is likely to be informationally demanding, depending inter alia on the distribution of projects.

As in the previous section, if intermediaries can monitor project returns, they should be able to offer equity contracts that are contingent on R. The nature of such contracts are as in Section 4. Entrepreneurs with project return R will choose their preferred form of finance by comparing profits under equity financing, $\pi^E(p, R, \sigma_R) = \sigma_R pR - y$, with that under a pooled debt contract, $\pi^D(p, R, r) = p(R - (1 + r)B) - y$. Debt will be preferred to equity, for given R, if $(1 + r)B < (1 - \sigma_R)R$. From the zero-expected-profit condition of intermediaries,

$$(1 + r)B = \frac{(1 - \overline{p})c + (1 + \rho)B}{\overline{p}}, \qquad (1 - \sigma_R)R = \frac{c + (1 + \rho)B}{\overline{p}_R} \tag{16}$$

where $\overline{p}_R$ is the average probability of success of equity-financed projects of return R. Therefore,

$$\pi^D(p, R, r) > \pi^E(p, R, \sigma_R) \qquad \text{if} \qquad \frac{\overline{p}}{\overline{p}_R} > 1 - \frac{\overline{p}c}{(1 + \rho)B + c} \tag{17}$$

Thus, equity will only be chosen for those R-type projects whose average probability of success exceeds that for debt-funded by enough to compensate for the higher cost required to monitor all projects ex post.

For those projects that are equity-financed, over-investment will occur, as we have seen in Section 4. However, there is no longer a presumption of over-investment more generally, since unlike in the earlier analysis of this section, there is now no guarantee that projects with low values of R—those that under debt finance are prone to under-investment—will be financed by equity rather than debt. Which projects will be equity-financed depends

[12] Again, a comparison with Myers and Majluf (1984) is apt. They argue that for existing firms, while there will be under-investment in some high-quality projects under new share financing, debt finance will lead to optimal investment choices. Of course, optimality in their context is from the point of view of existing shareholders: they do not consider social benefits.

on the distribution of p, about which nothing in general can be said. We thus return to the agnostic policy prescriptions of the debt-only case. There may well be some low-return, low-risk projects—those associated with region D in Figure 1—that are not undertaken but should be. All we can say is that the extent of under-investment in low-R projects might be reduced by the possibility of equity finance.

6. Extensions

This section considers some extensions to the analysis above, mostly involving enhancements of the information available to the intermediaries. Here we restrict attention to the case in which only debt finance is available. This is partly for simplicity but also, and more importantly, because the results above suggest that the availability of equity finance mitigates the ambiguity in the direction of inefficiency, and hence of appropriate policy. Thus the purpose here is to see if various key extensions also lead to clearer conclusions in the debt-only case.

We deal first with two cases in which banks may be able to separate projects of different types by separating contracts, and then consider the outcome when entrepreneurs can, at some cost, signal the quality of their projects to banks. For simplicity, we assume throughout this section that monitoring costs are zero.

Different Capital Requirements

Suppose that project size K is variable, and that project returns are given by the function $R(K)$, where $R' > 0 > R''$. If entrepreneurs differ only by their probability of success p, all would choose the same level of K for any given r and so could not be separated by the banks. To make the case of variable capital size substantive, we assume that entrepreneurs also vary by an ability parameter a. And, to avoid multi-dimensional screening problems, we further assume that abilities and probabilities of success are perfectly correlated: all entrepreneurs of a given ability a have the same probability of success p. For expositional purposes, suppose initially there are only two types of entrepreneurs, differing in their probability of success p_i $(i = 1, 2)$ and their ability a_i, both of these characteristics being private information to the entrepreneur. Type 2's are taken to be more able, so that $a_2 > a_1$, but alternative possibilities on their relative chances of success ($p_1 \gtrless p_2$) can apply. Later we consider the case where entrepreneurs can take on many different abilities in order to address the issue of whether the efficient number of projects is financed.[13]

Output of type i if successful is $a_i R(K)$. In the event of failure, output is zero, as above. Assuming entrepreneurs have no initial wealth (so $K = B$), the expected profit of a type

[13] The case of separating financial market equilibria with two ability types is considered in some detail in Takalo and Toivanen (2004).

i is:

$$\pi_i = p_i(a_i R(B) - (1+r)B) - y \tag{18}$$

Preferences of the two types over (r, B) contracts can then be represented by zero-profit contours. By differentiating (18), these have an inverted-U shape, with the direction of increasing profit being downwards and with the curves for the high-ability types peaking, at any given r, to the right of those of with low ability. Moreover, a single-crossing property holds: at each point in $(r, B)-$space, the slope of the zero-profit contour of the high-ability type exceeds that of the low-ability type. Given this, the possibility arises of a separating equilibrium in which the two types are offered, and select, different (r, B) contracts (as in Boadway *et al*, 1998). In any such equilibrium, each contract must earn zero expected profits for the bank (otherwise it would be vulnerable to entry). Since expected profits on a type i contract are $p_i(1 + r_i)B_i - (1 + \rho)B_i$, this requires that

$$1 + r_i = \frac{1+\rho}{p_i} \qquad i = 1, 2$$

where r_i is the actuarially fair interest rate associated with p_i.

Equilibrium is characterized by the banks offering contracts (r_i, B_i) which maximize expected profits subject to this zero-expected-profit condition for each type, the participation constraint that $\pi_i \geq 0$ for both types, and the incentive constraints that each type prefer the contract intended for it, so that

$$a_i R(B_i) - (1 + r_i)B_i \geq a_i R(B_k) - (1 + r_k)B_k \qquad i, k = 1, 2, \; k \neq i$$

Note that in the first-best allocation, each type maximizes $p_i a_i R(B_i) - (1 + \rho)B_i$, so that $a_i R'(B_i) = (1 + \rho)/p_i$, with strict concavity of $R(K)$ ensuring that the participation constraint is satisfied. Diagrammatically, this corresponds to a point of tangency between a zero-profit contour of type i and a horizontal line at the corresponding actuarially fair interest rate r_i.

Consider first the case in which both ability types have the same chance of success, so that $p_1 = p_2$. In this case, the first-best can be sustained as a separating equilibrium, as shown in Figure 5. The banks offer contracts at the common actuarially fair interest rate, so earning zero profits, but in quantities corresponding to the first-best levels of the two types. Each type prefers its own contract to the other, and there is no scope for an entrant bank to make a profit by offering a contract more attractive to either type (since to make a profit it would have to charge an interest rate higher than r, which would imply lower profits for both types). With the no-intervention outcome fully efficient, there is no scope for activist policy in this case. More generally, suppose there is a population of potential entrepreneurs differing in their ability a_i. Since profits π_i will be declining in a_i, there will be a marginal ability level $\tilde{a}$ such that profits are just zero. All potential entrepreneurs with ability level $a_i \geq \tilde{a}$ will choose to be entrepreneurs, and the outcome will be fully efficient.

Turning now to the cases in which p_1 and p_2 may differ, the no-intervention separating equilibrium will still be first-best if the probabilities of success are sufficiently similar and/or abilities sufficiently dissimilar so the incentive constraints do not bind. The more interesting case, however, is that in which the incentive constraints do bind, leading to an inefficient separating equilibrium. Such an equilibrium will have the features (irrespective of whether p is larger for the high- or the low-ability type) that the low-p type will be offered a contract corresponding to its first-best level of investment, and only that type will face a binding self-selection constraint.

Suppose, for illustrative purposes, that the high-ability types are also the more likely to succeed, so that $p_2 > p_1$. And, assume that the probabilities of success are sufficiently different that the incentive constraints are not all slack. The relevant separating equilibrium—assuming there are enough type 1's so it exists—is shown in Figure 6. The low-ability types are offered their first-best contract at α but the high-ability types are required to over-invest at β relative to their first-best level at γ.

Policy can improve on this outcome. To see how, note first that there would be a social gain if the high-ability types could be induced to accept a contract at δ (slightly northwest of β, and on the same zero-profit contour of the low-ability type) rather than β, since this would bring their level of investment closer to the first-best level. The difficulty is that although the pair (α, δ) is incentive-compatible it cannot be sustained as a no-intervention equilibrium because δ (since it involves an interest rate higher than r_2) leaves the banks with positive profits. But the government can soak up these profits by imposing a tax on the interest payments associated with the high-ability contract. More precisely, by charging a tax on the low-interest loans equal to the vertical distance between δ and β, the government can induce banks, solving the problem described above, to offer the contract at δ, and they will earn zero net profits by doing so. This tax makes high-ability entrepreneurs worse off, of course, so that this argument will fail if it leads to a violation of their participation constraint. It is readily verified, however, that their participation constraint is not binding in the no-intervention equilibrium, and so will continue to hold for a sufficiently small tax. The participation constraint may make it impossible to sustain the first-best as an equilibrium in this way by charging a high enough tax to induce the contract at ζ, directly above γ, but a small tax is sure to be improve welfare.

Suppose now that there are a large number of potential ability-types of entrepreneurs, with higher ability-types having higher probabilities of success. Following the same reasoning as above, it is clear that the optimal number of entrepreneurs will be financed. The lowest ability entrepreneurs receive their first-best level of finance, and the marginal one will obtain zero profits. Since the banks are able to offer them a separate contract, the probability of success of the marginal entrepreneur will also reflect the probability of repayment to the bank. This implies that the social profitability of the marginal entrepreneur's project will also be zero, so again the optimal number will enter. The loans to all but the lowest ability types, however, will be inefficiently large.[14]

A parallel analysis applies for the case in which it is the low-ability types that are more likely to succeed, so that $p_2 < p_1$. The separating equilibrium is in this case as shown in Figure 7, with the low-ability types credit-constrained in the sense that their contract implies under-investment. By essentially the same argument as above, the outcome can again be improved by imposing a tax on the low interest loans, shifting the low-ability types from β to a point like ζ. The participation constraint raises somewhat more delicate issues in this case, since there is no assurance that it does not bite for the low-ability types in the no-intervention equilibrium. In particular, if there is a spectrum of ability types, entry will occur until the least profitable type just earns zero profits. The least profitable type can be of high or a low ability since ability and probability of success work in opposite directions. If the low-ability entrepreneurs also earn the least profits, correcting for the under-investment by imposing a tax on credit-constrained entrepreneurs can cause an offsetting distortion by forcing some of them out of business. With that proviso, however, the case for a tax on low-interest loans carries through essentially unchanged.

It is striking that the qualitative nature of the optimal policy is the same irrespective of whether it is the low- or high-ability types that have the greater prospect of success. Since the inefficiency being addressed involves over-investment in one case and under-investment in the other, one might have expected a tax and subsidy to be optimal in the two cases. The key point, however, is that the inefficiency is being induced not by setting an inappropriate interest rate but by a distortion in the amount of credit being made available, The tax acts not directly on investment, but on the self-selection constraint that induces the inefficiency. By making the low interest loans less attractive, the tax weakens the incentive constraint—making the low interest loan less attractive to the low-p type—and so shifts the equilibrium to the social optimum.

One further implication of these results should be noted. Suppose that for some reason the government cannot distinguish between low- and high-interest loans. Then, it can be shown that a small tax on all loan interest might be desirable. For although it is better to tax only low-interest loans and so leave the investment decision of the low-p (high-r) entrepreneurs unchanged, a small distortion of their decisions causes no first-order welfare

[14] More formally, the zero-profit condition of the marginal entrepreneur implies: $\tilde{p}(\tilde{a}R(\widetilde{B}) - (1+\tilde{r})\widetilde{B}) - y = 0$, where tildes refer to values for the marginal entrepreneur. Since $\tilde{p}(1+\tilde{r}) = (1+\rho)$, this zero-profit condition becomes $\tilde{p}\tilde{a}R(\widetilde{B}) - (1+\rho)\widetilde{B} - y = 0 = S(\tilde{p})$. Thus, the marginal entrant earns zero social profit.

loss (since they start at the social optimum).

The generality of the desirability of taxing loan interest in this model is striking. Nevertheless, the limits of this result should also be noted: inefficiency cannot be inferred, for instance, from the co-existence of two interest rates, since there are cases in which this may sustain a fully efficient outcome;[15] and the participation constraints can limit the range in which a tax on loan interest is desirable. The result is, nevertheless, suggestive.

Different Collateral Requirements

If entrepreneurs have initial wealth, it is possible for the banks to separate projects using differential collateral requirements, at least in the simple case where firms differ in one dimension only.[16] Consider again the de Meza-Webb case where firms differ in p, but have the same R. Let C be the amount of collateral that the firm must pay in the event of bankruptcy. Given wealth W, collateral is limited by $0 \leq C \leq W$. The expected profits of the firm become:

$$\pi(r, C) = p(R - (1 + r)B) - (1 - p)C - y$$

Note that $\partial\pi/\partial C < 0$, since firms dislike collateral. The possibility of a separating equilibrium revolves around which types of firms dislike it more. The slope of a zero-profit curve now becomes:

$$\left.\frac{dr}{dC}\right|_{\pi} = -\frac{(1 - p)}{pB} < 0$$

Since this slope is independent of both r and C, zero-profit loci are straight lines. To verify a single-crossing property, differentiate with respect to p to obtain:

$$\frac{d}{dp}\left[\left.\frac{dr}{dC}\right|_{\pi}\right] = \frac{1}{p^2 B} > 0$$

Thus, the higher-p firm has flatter zero-profit curves. This gives rise to the possibility of separating contracts.

Figure 8 illustrates this for the case of two types with $p_2 > p_1$. With no collateral, type 1's would prefer the interest rate appropriate for the type 2's, r_2. It is possible to design a contract for the high-p types to separate them from the low-p potential mimickers. The optimal separating contract is given by (r_2^*, C_2^*) such that the type 1's are just indifferent between this contract and their no-collateral first-best interest rate r_1. The interest rates charged to the entrepreneurs depend on the banks' zero-expected-profit condition. For the

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15 Even in this case, however, there would at least be no first-order welfare loss from a small tax.

16 Another potential means of separating projects might be by using differing internal financing requirements. However, it is straightforward to show that the only equilibrium in this case is a pooling one.

low-p types who have no collateral, $p_1(1 + r_1) = 1 + \rho$. For the high-p types, the interest rate satisfies $p_2(1+r_2^*)B+(1-p_2)C_2^*-(1+\rho)B = 0$. This is less than the full information interest rate, r_2^*, because of the effect of collateral. However, this separating contract may or may not be an equilibrium in the Rothschild and Stiglitz (1976) sense. Only if the pooling interest rate exceeds $\hat{r}$—that is, if there is a large enough proportion of high-risk types—will a separating equilibrium exist.

Suppose now there are a large number of potential types of entrepreneurs, who differ in their probability of success. As above, the single-crossing property will apply between any pair of probability types, with zero-profit curves being flatter for higher p's. Assuming that separating equilibria exist, as many types of contracts will be offered as there are probability types (so long as there is no bunching (partial pooling)).[17] Incentive constraints for a given p-type entrepreneur will be binding only on the adjacent entrepreneur with the next lowest p. Profits will be increasing monotonically with p. If there is a pool of potential entrepreneurs, entry will occur until the profits of the last one fall to zero. Since the lowest-p entrepreneurs face no incentive constraint (analogous to type-1 in Figure 8), the marginal entrepreneurs obtain their first-best level of finance, and they earn zero expected profits. Since the banks are able to offer them a separate contract, the probability of success of the marginal entrepreneur will also reflect the probability of repayment to the bank, or $\tilde{p} = \overline{p}$ in the notation of basic model. This implies that social profitability of the marginal entrepreneur's project will also be zero. There is therefore no need to intervene to ensure that the optimal number of entrepreneurs receive project financing: the first-best tax is zero.

Signaling by Entrepreneurs

Suppose finally that entrepreneurs can signal their types perfectly by incurring a fixed cost f. Signaling of this sort is considered by Fuest et al (2003) for the de Meza-Webb and Stiglitz project distributions: here we consider it for the general case. Potential entrepreneurs now choose from three options: signal and take a loan, not signal and take a loan, and not take a loan. For entrepreneurs that signal, banks learn perfectly their type and can charge a type-specific interest rate. The typical banks' zero-expected-profit condition—the analog of (6)—implies that the interest rate charged to them (assuming for simplicity $c = 0$) satisfies $1 + r = (1 + \rho)/p$, so r is decreasing in p. For those who choose not to signal, the pooled interest rate obtained from the bank zero-expected-profit condition (6) satisfies $(1 + r)\overline{p}^n = 1 + \rho$, where $\overline{p}^n$ is the average probability of success of funded projects of entrepreneurs that do not signal.

[17] For an analysis of separating equilibria with many different types of agents, see Guesnerie and Seade (1982). We assume away bunching since it has no effect on the qualitative results of interest to us.

Entrepreneurial expected profits for those who do and do not signal are then given by, respectively:

$$\pi^s(p, R) = pR - (1+\rho)B - y - f$$

$$\pi^n(p, R, r) = p\left(R - (1+\rho)\, B/\overline{p}^n\right) - y$$

Entrepreneurs who take a loan will signal if $\pi^s \geq \pi^n$, or

$$(1+\rho)(p/\overline{p}^n - 1)B - f \geq 0 \tag{19}$$

Denote the probability of success of the marginal entrepreneur who signals by $\hat{p}$, which is the value of p such that (19) is satisfied with equality:

$$\hat{p} = \overline{p}^n \left(1 + \frac{f}{(1+\rho)B}\right) > \overline{p}^n$$

Entrepreneurs with $p \geq \hat{p} > \overline{p}^n$ will signal and obtain expected profits $\pi^s(p, R)$, while those with $p < \hat{p}$ who take a loan will not signal and will obtain expected profits $\pi^n(p, R, r)$.

Figure 9 illustrates this for the general case. In the absence of signaling, the average probability of success of funded projects is $\overline{p}$. Signaling by the high-p entrepreneurs causes the interest rate to rise for non-signaled projects, since this pool now has a lower expected probability of success, $\overline{p}^n < \overline{p}$. The zero-profit curve for pooled projects—those with $p < \hat{p}$—shifts parallel outward from $\pi(p, R, r) = 0$ as shown. However, for $p > \hat{p}$, the zero-profit curve to $\pi^s(p, R) = 0$ is a rectangular hyperbola $pR = (1+\rho)B + y + f$, so parallel to the zero-benefit curve, $S(p, R) = 0$. The area of over-investment will fall, but the area of under-investment may well rise. Moreover, the deadweight cost of signaling is incurred. On balance, therefore, the ability of entrepreneurs to signal their quality may or may not be welfare-improving. Equivalently, there may be too much or too little signaling compared with the socially optimal amount. The important point for present purposes, however, is that the key qualitative result of the non-signaling case carries over: there will be too many low-p and too few high-p projects undertaken, and, unless the government has enough information to be able to target tax rates by p, the optimal direction of intervention is ambiguous.

That the de Meza-Webb result continues to hold can be seen from Figure 9, drawn for a given return $\overline{R}$. In the absence of signaling, we have $\overline{p} > \tilde{p}$. Signaling will peel off the highest p projects, causing $\overline{p}$ to fall to $\overline{p}^n$ and the pooled interest rate r to rise. As long as some projects do not signal in equilibrium, we have $\hat{p} > \overline{p}^n > \tilde{p}^n$, where $\tilde{p}^n$ is the probability of success of the marginal project. Since the pooled interest rate rises, $\tilde{p}^n > \tilde{p}$, so there will be fewer projects funded. However, as long as some pooled projects remain, there will be more projects than is socially optimal, by the same reasoning as before. Signaling itself will have ambiguous effects on welfare. Fewer projects will be funded, which is a good thing in the de Meza-Webb case. But costs of signaling will be incurred, which is wasteful: those who signal would have been funded anyway. The effect of signaling on them is simply to reduce the interest rate they face, which is a pure transfer from the banks. On balance, the welfare effect of signaling is ambiguous.[18] However, the policy implications are not affected by signaling. As in the de Meza-Webb case without signaling, it will be efficient to tax loans or funded projects. As Fuest et al (2003) argue, a tax will reduce the number of lowest-p projects funded, which is welfare-improving. It will also reduce the number of entrepreneurs who chose to signal, which reduces social costs. The reason is that with the lowest-p projects leaving the pool, the interest rate on pooled projects falls, causing $\hat{p}$ to rise.

In the Stiglitz-Weiss case (assuming that all projects are socially beneficial, and corresponding to the analysis in Section 3 for the case in which $c = 0$), either $\hat{p} > \tilde{p} > \overline{p}$ or $\tilde{p} > \hat{p} > \overline{p}$. If $\tilde{p} > \hat{p} > \overline{p}$, all projects are funded, which is good. The need for policy to discourage entry of projects is supplanted. However, the cost of signaling is incurred so the social optimum is not achieved. In fact, as in the de Meza-Webb case, signaling might be either welfare improving or welfare deteriorating.

7. Summary and Conclusions

We began by generalizing the previous literature to characterize the nature of credit-market inefficiency when the distribution of projects, in terms of their return if successful, R, and chance of success, p, can take any form, finding that there will generally be under-investment in projects with low R and high p, and over-investment in projects with high R and low p. In principle, an appropriate non-linear tax that is decreasing in the probability of success (and subsidizes projects with better-than-average chances of success) can implement the first-best. But this is effectively impossible to implement, since the probability of success is hard to identify: indeed if it were not, there would be no market inefficiency to correct. An attractive alternative is an income tax levied on self-reported ex post income. To the extent that an audit and enforcement system succeeds in inducing entrepreneurs to report their income truthfully, efficiency could be improved by a progressive tax in entrepreneurial returns in which the rate of tax increases with returns.

The ambiguity is mitigated, however, whenever equity finance is available to entrepreneurs. If only equity finance is used, over-investment will occur regardless of whether all projects are pooled using a common equity contract or whether return-specific contracts are used. The latter is a seemingly feasible option given that ex post returns must be verified for equity contracts to be consummated. If entrepreneurs are offered the choice between

[18] Fuest et al (2003) show that if firms are distributed uniformly over p, signaling will be excessive. A tax on signaling would be welfare-improving, if it could be implemented.

debt and equity contracts, efficiency depends on whether equity contracts are pooled or differentiated by return. In the former case, high-R projects opt for debt finance, low-R projects opt for equity finance, and there are unambiguously too many projects of each type undertaken. The policy conclusion is then clear-cut. Although reaching the full optimum is informationally demanding, depending on the overall pattern of returns, the direction of intervention is straightforward: welfare would be increased by a small tax on all projects (with it being immaterial, in these models, whether this is imposed as a tax on the profits of successful projects, on payments by entrepreneurs to intermediaries, or on intermediaries' payments to depositors). Once equity contracts are return-specific, the outcome is ambiguous. While there is over-investment by entrepreneurs who opt for equity, debt contracts will again lead to over-investment for high-R projects and under-investment for low-R projects as in the debt-only case.

The various extensions to the debt-only case considered here preserve and in some respects strengthen the tenor of these results. If banks are able to offer separating contracts by exploiting differences in projects' capital requirements then (while there will be no inefficiency in the number of projects funded) there is an inefficiency in the size of loans offered—which can be eased by imposing a tax on low-interest loans (and in some circumstances on all loans), since this weakens the binding self-selection constraint. When banks use differing capital requirements to separate projects, on the other hand, the market outcome leads to an efficient number of projects financed; and there is at least no first-order welfare loss from imposing a small tax. When entrepreneurs can, at some cost, signal the profitability of their projects, however, the underlying inefficiency remains as in the basic debt-only case, and the appropriate direction of corrective policy is uncertain.

It would clearly be dangerous to draw any strong conclusions for policy from the results here. They rest on a number of simplifying assumptions that, while commonplace in the literature, merit relaxation. Prominent amongst these is the assumption that both entrepreneurs and creditors are risk-neutral, which rules out risk-sharing as a function of credit markets.[19] Moreover, the results are clearly quite model-specific. Given too the recurrent ambiguity when only debt finance is available, it is tempting to invoke the principle of insufficient reason to conclude that the best policy is not to seek to impose any corrective tax or subsidy at all. That may indeed be the wisest conclusion in the present state of knowledge. If one were to be more speculative, however, there are clear hints in the results here of potential gains from a more nuanced approach: the wider the financial opportunities open to entrepreneurs—in terms, in particular, of their access to

[19] We have also assumed away moral hazard on the part of either the entrepreneurs or the intermediaries, and ruled out ex ante monitoring activities by the banks. Some consequences of the former are considered in de Meza and Webb (1999), de Meza (2002) and Keuschnigg and Neilsen (2004), and of the latter for the case of debt finance by Boadway and Sato (1999).

equity finance—the stronger tends to be the case for a corrective tax on investments by new firms.

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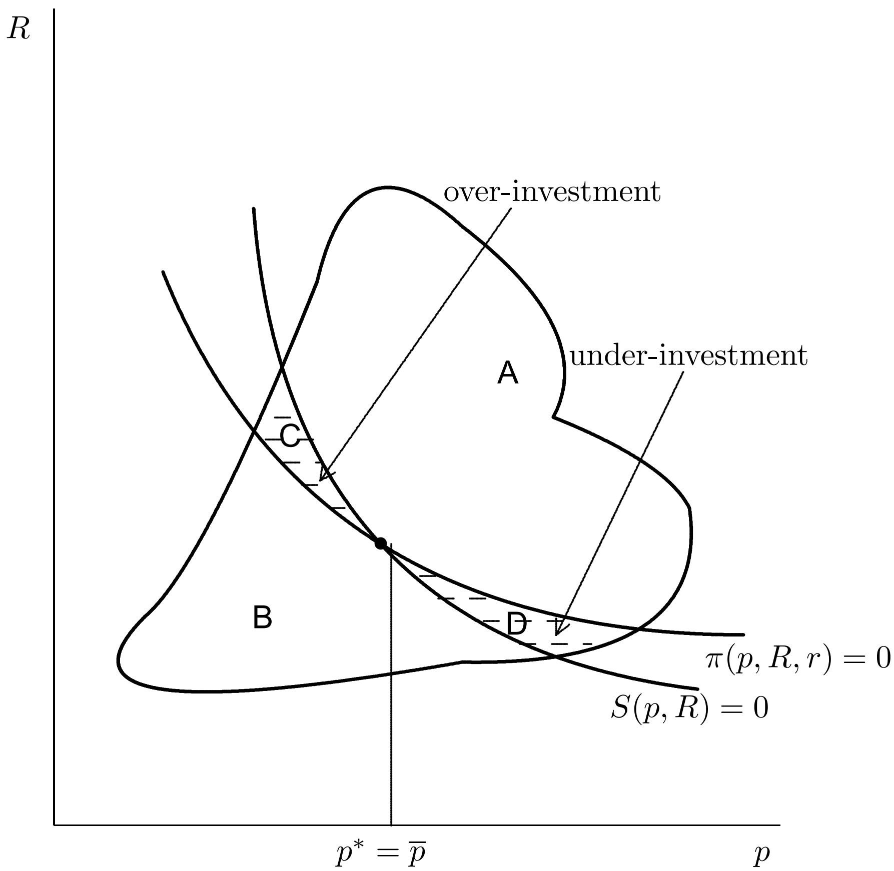

Figure 1. Debt-only: The General Case

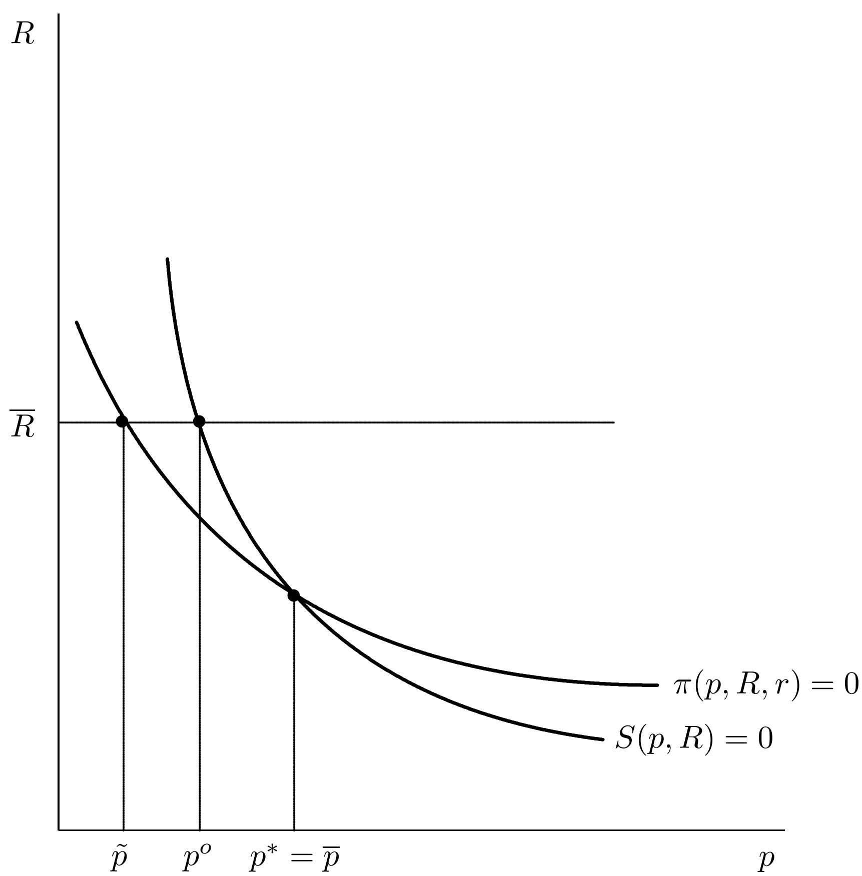

Figure 2. The de Meza-Webb Case

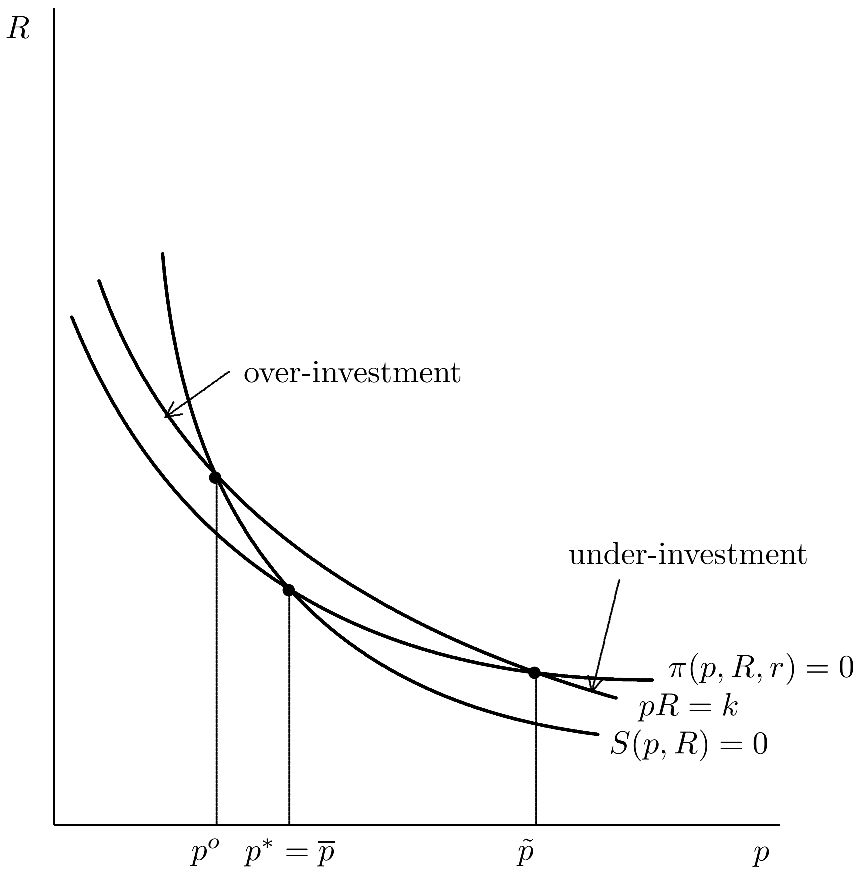

Figure 3. The Stiglitz-Weiss Case with $c > 0$

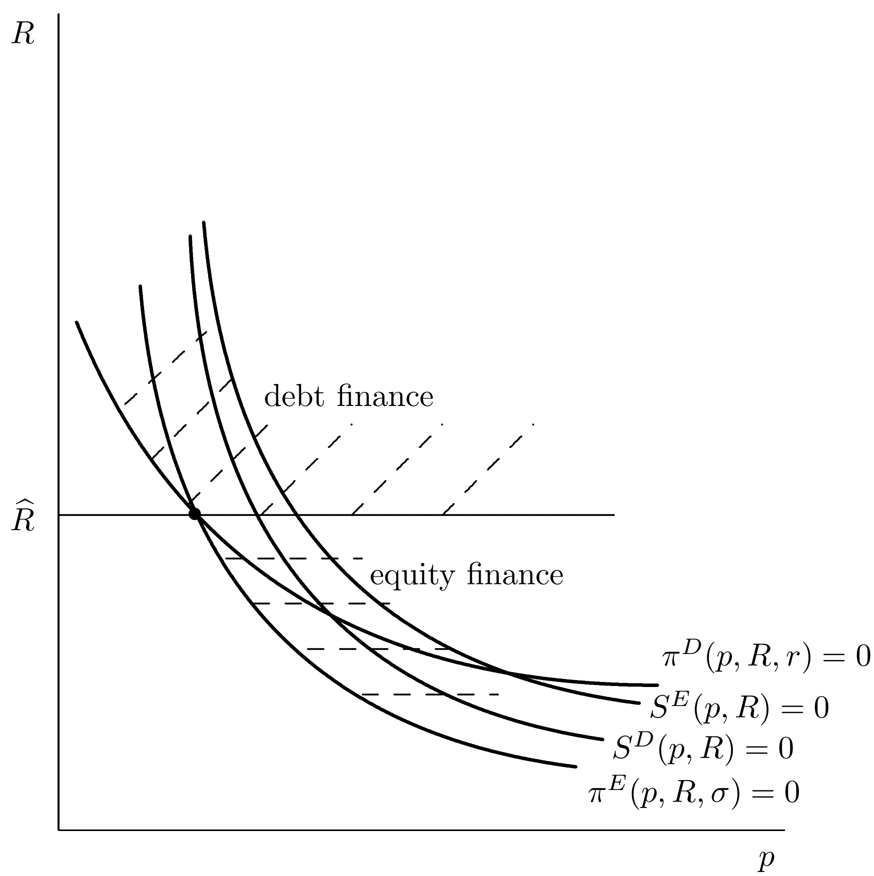

Figure 4. Debt and Equity Finance

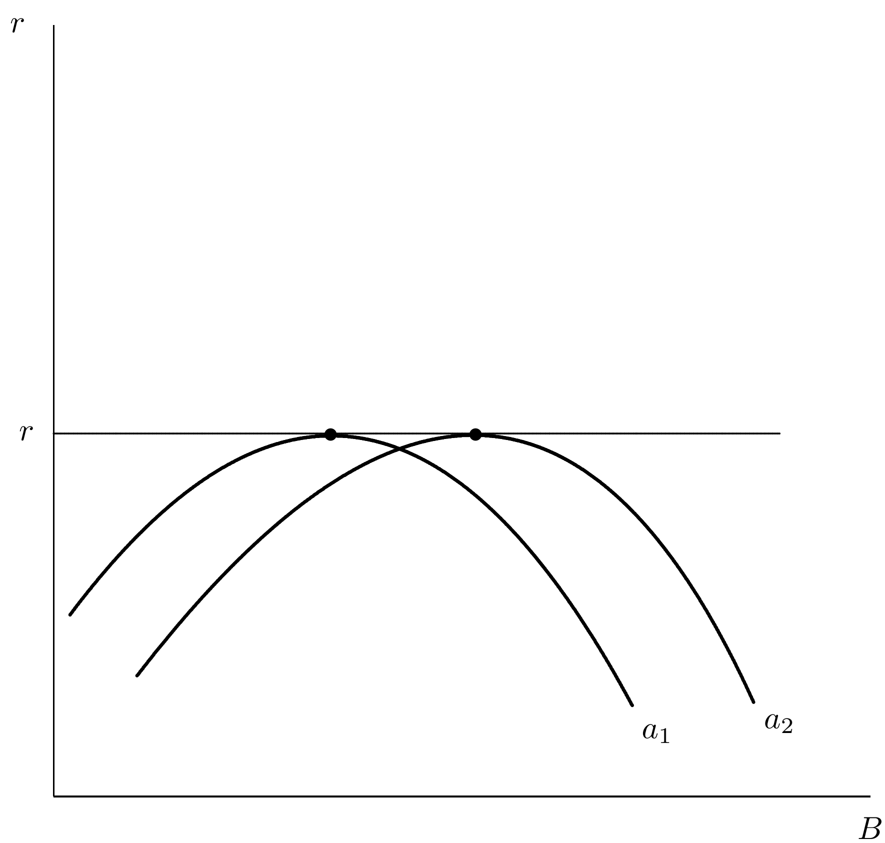

Figure 5. Success Probabilities Identical

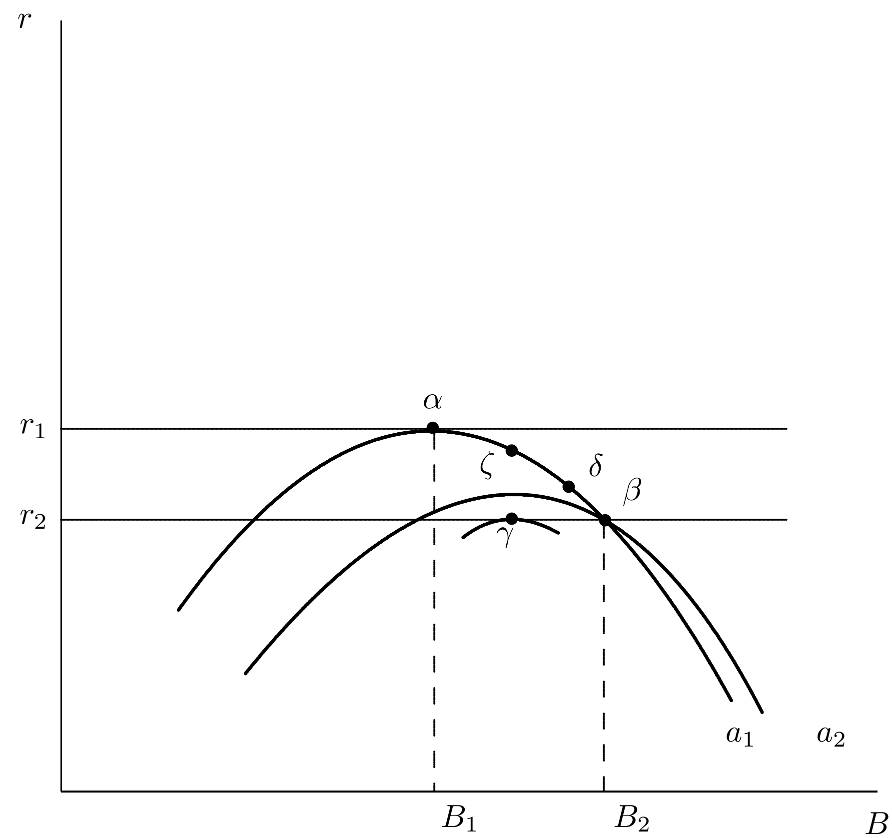

Figure 6. Ability and Success Probability Positively Correlated

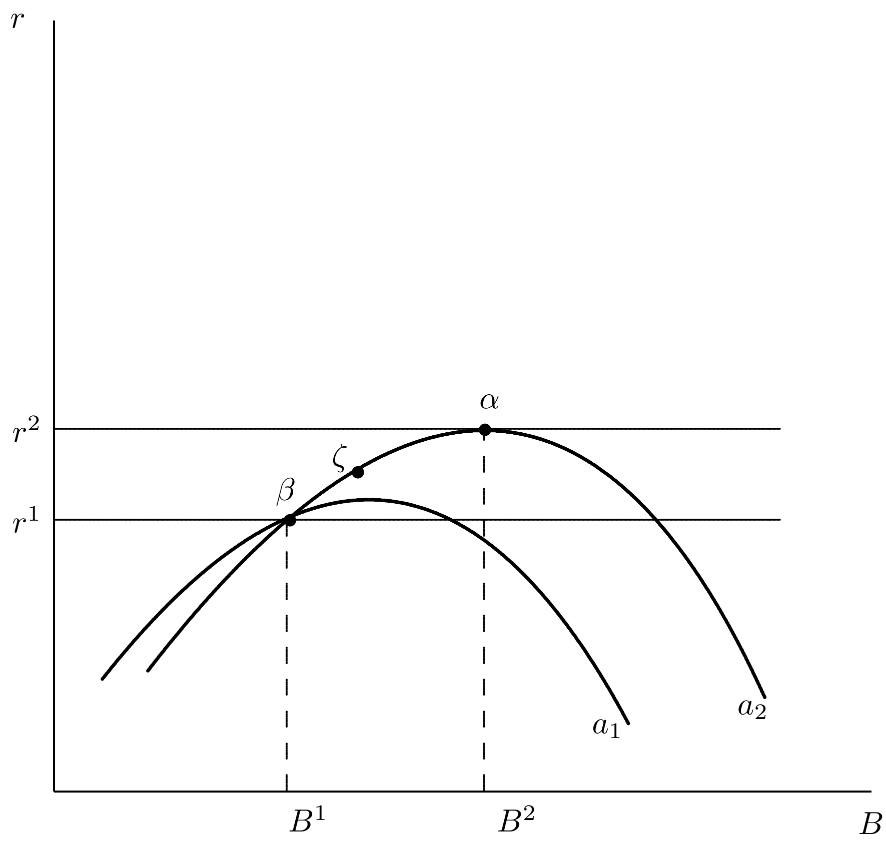

Figure 7. Ability and Success Probability Negatively Correlated

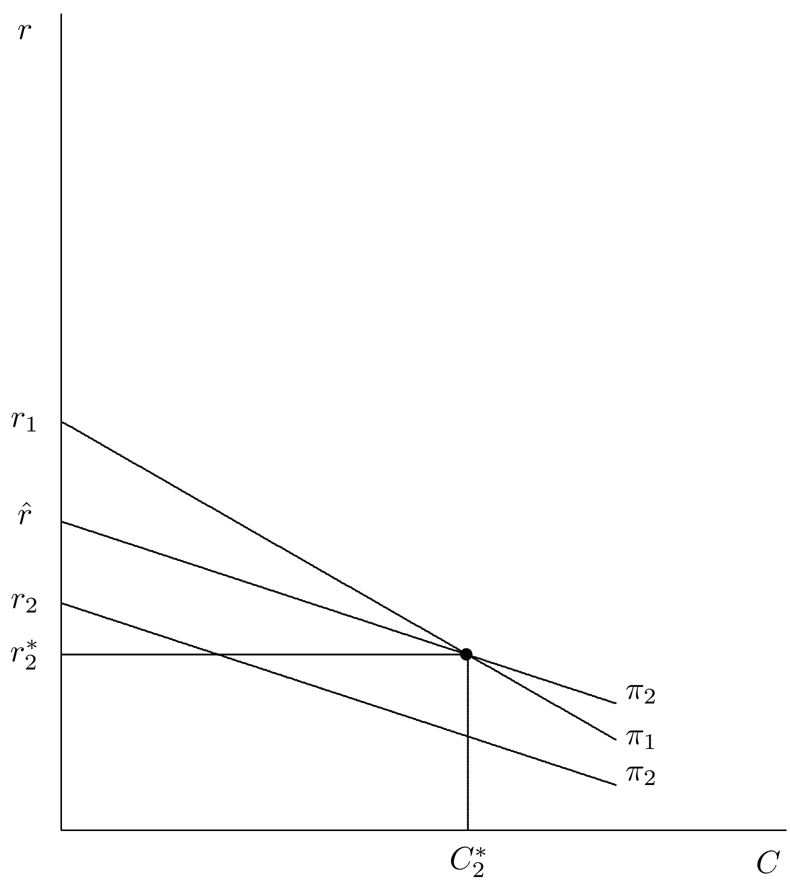

Figure 8. Variable Collateral Requirements

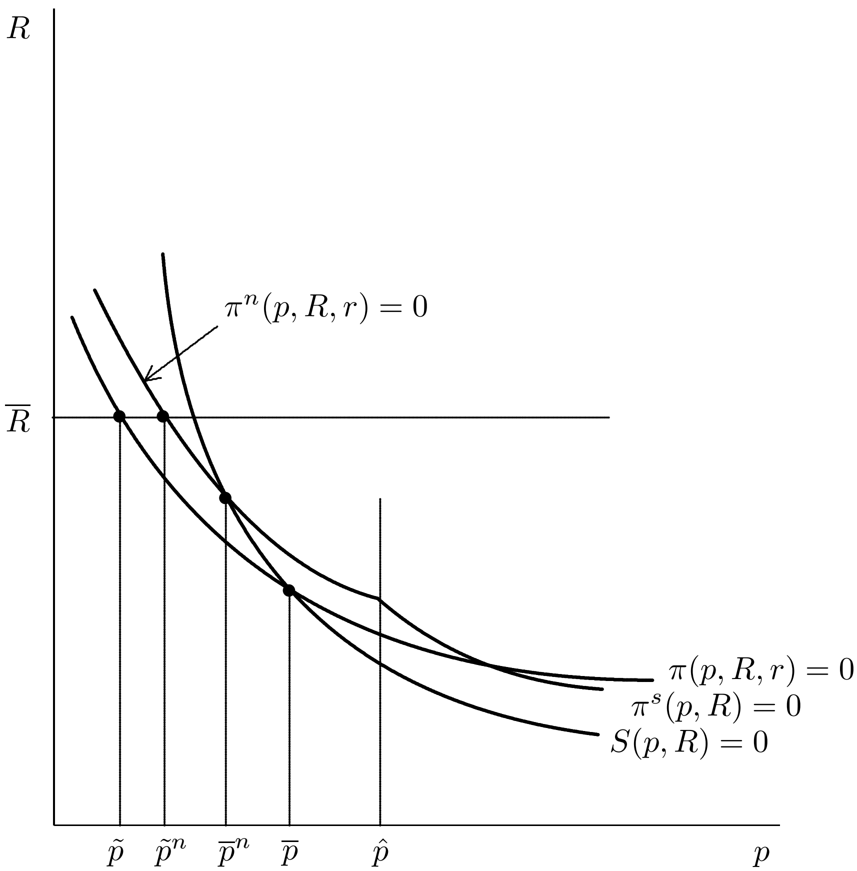

Figure 9. The Signaling Case with Debt Finance