RAND Journal of Economics
Vol. 30, No. 2, Summer 1999
pp. 324–350

Banking (conservatively) with optimists

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Commercial banks frequently encounter optimistic entrepreneurs whose perceptions are biased by wishful thinking. Bankers are left with a difficult screening problem: separating realistic entrepreneurs from optimists who may be clever, knowledgeable, and completely sincere. We build a game-theoretic model of the screening process. We show that although entrepreneurs may practice self-restraint to signal realism, competition may lead banks to be insufficiently conservative in their lending, thus reducing capital-market efficiency. High collateral requirements decrease efficiency further. We discuss bank regulation and bankruptcy rules in connection with the problems that optimistic entrepreneurs present.

1. Introduction

■ In the course of ordinary business, commercial banks frequently encounter entrepreneurs seeking loans to finance new or continuing projects. Most such entrepreneurs, even those well informed about related business and technology, are convinced that the proposed project would be successful and profitable if funded. Yet this optimism is frequently unrealistic, the perception of the entrepreneur having been biased by wishful thinking. Bankers (and venture capitalists) are left with a difficult screening problem: the need to separate realists from optimists who may be clever and knowledgeable and completely sincere in their optimistic beliefs. The resolution of this screening problem will in part determine the fate of entrepreneurs and the overall efficiency of the credit market.[1]

A bias toward optimistic expectations is a common characteristic of human perception. This fact has been well established by cognitive psychologists in hundreds of empirical studies. Psychologist Shelley E. Taylor sums up much of the evidence on this point in her comprehensive book on the subject (Taylor, 1989). In fact, Taylor

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We are indebted to Denis Gromb, Bengt Holmström, Glenn Loury, Dilip Mookherjee, Zvika Neeman, Debraj Ray, Michael Riordan, and Robert Rosenthal, the Editor David Scharfstein, and two referees for their comments and assistance. We would like to thank CEMFI and the Industrial Studies Program of Boston University for funding and assistance to the visiting coauthors.

[1] The problem of optimistic entrepreneurs whose identity is known is explored by de Meza and Southey (1996). We discuss their article in Section 4.

applies this evidence to support her argument that unrealistic optimism is an indispensable trait of the healthy mind.

De Bondt and Thaler (1995, p. 389), in their summary of recent studies made both by behavioral economists and by psychologists and sociologists, report that ''perhaps the most robust finding in the psychology of judgment is that people are overconfident,'' that is, people are unrealistically optimistic about their ability, power, and the outcome of their own actions. Adam Smith, always a keen observer, discussed both overconfidence and optimism in general in *The Wealth of Nations* (1776, Book I, Chapter X), where he notes:

> The overweening conceit which the greater part of men have of their abilities is an ancient evil remarked by the philosophers and moralists of all ages. Their absurd presumption in their own good fortune has been less taken notice of [but is], if possible, still more universal. . . . The chance of gain is by every man more or less overvalued, and the chance of loss is by most men undervalued. . . .

As evidence for these assertions, Smith cited several facts pertaining to 18th century Britain: most houses and many ships at sea were uninsured, young people gave little weight to downside risk in their career choice, and wages were not significantly elevated in certain classes of dangerous jobs.

One might argue that because optimism and pessimism are symmetric deviations from accurate perceptions, they require symmetric treatment in economic models such as the one we shall employ here. We believe that this notion is incorrect. The empirically established human bias toward overoptimism and overconfidence is most evident in connection with areas of self-declared expertise (De Bondt and Thaler, 1995). Thus, the decisions of entrepreneurs on the implementation of their own ideas are more likely to reflect excessive boldness than excessive conservatism. Moreover, the excessively bold entrepreneur can be expected to apply more resources in pursuit of his objective than the excessively conservative one will, so that unrealistic optimism is likely to be far more costly than its counterpart in pessimism. Finally, entrepreneurs are very much a self-selected group. Pessimists, who might tend to be excessively conservative as entrepreneurs, would be likely to select other occupations whose outcomes are more predictable, less variable, and thus less subject to their own pessimistic expectations; that is, they might prefer to be workers, librarians, or economists[2] rather than entrepreneurs (see the discussion in de Meza and Southey (1996)). For these reasons, we shall model entrepreneurial types who range between realistic and optimistic, and we ignore the possibility of pessimistic ones.

In this article we are concerned with a type of optimism that may characterize large numbers of entrepreneurs: a tendency to exaggerate the range of applicability of a truly productive idea. For example, an entrepreneur may have an idea of how to design and develop a particular software application. His software product would in fact be very useful for a particular class of firms, but the optimistic entrepreneur wrongly believes that his product can be designed in a way that would make it useful for almost all firms, provided only that he can raise sufficient funds for its development. If he locates the needed funds, he will attempt to complete his project on a grand scale, but he will fail and go bankrupt. The result is costly to society: not only will society lose a good part of the capital investment in this unsuccessful endeavor, but it will also lose the potential benefits of the idea as applied in a more limited scale.

[2] In this unusual field, pessimism may be sold as a product, which can fetch a handsome price when cleverly marketed.

The behavior of optimistic entrepreneurs described in this article is similar to what we would expect of empire-building managers, who derive private nonpecuniary benefits from building and operating corporate empires. Like optimists, they would tend to commit resources to grandiose, possibly inefficient investment projects. Consequently, we could have chosen to interpret the agents depicted here as empire builders rather than optimists. We chose not to do so for three reasons. First, unlike optimists, whose actions are based on misperceptions about project quality, empire-building managers would be fully aware of the true value of their investments. Because of this, the natural focus of an analysis of empire building would be the design of a mechanism to induce agents to make appropriate use of their information. In our framework, the agents we call optimists have no information about the quality of investment projects (though they believe otherwise). Second, because the nonpecuniary benefits to empire builders are real, the welfare consequences of empire building are somewhat different from those of optimism. Third, whereas there is a substantial body of evidence to support the argument that optimism and overconfidence are important and widespread in the population,[3] there is not a comparable body of evidence to support the existence of an ''edifice complex'' among managers.

Every year, large numbers of possibly optimistic entrepreneurs (or would-be entrepreneurs) come up with ideas for what they perceive as profitable projects. Many of those projects, probably most of them, have no profit-making potential, and we suspect that most of those projects die for lack of funding. Of those that do have a profit-making potential, the scale and range of the development effort can be important. A development effort that is either overly conservative or overly bold may fail, even when an effort of the right size would succeed.

The market has a large number of institutions for dealing with overconfidence and excessive boldness among entrepreneurs. Banks and other lending institutions serve as a first line of defense. Frequently, they constrain the scale of a project-development effort by limiting available funds or raising interest rates. These responses to optimism may in themselves have a significant social cost, because they discourage optimal investment in meritorious projects as well as overinvestment in lesser ones.[4] But this leads to an important question about lending institutions. It is widely thought that market considerations lead banks to be overly conservative and cautious, discouraging the rational buyer more than is desirable. Here, we demonstrate that in markets with optimistic entrepreneurs, the opposite may well be true. This is because competitive banks do not capture in their interest rate the opportunity cost to the optimistic entrepreneur that stems from his failure to profit from an investment of the appropriate size.

This result, that banks may fund inefficient investments, also emerges from the empire-building literature. Banks are willing to lend excessive amounts to optimistic entrepreneurs for the very same reason that they are willing to lend to financially healthy firms with potentially inefficient investments, which may be undertaken because of empire building or any other asymmetric-information problem. Banks set the interest rates on their loans so as to obtain an adequate compensation for their invested funds, and they need have no concern for their borrowers' welfare no matter whether the borrowers are optimists, opportunistic managers, or plain crooks.

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[3] See the articles described above and their references.

[4] This effect may be even more pronounced in factor markets with upward-sloping supply curves. As Manove (1998) demonstrates, optimists may overuse scarce resources in equilibrium and thus bid up the prices that realists must pay. In the words of Warren Buffett, ''It's optimism that is the enemy of the rational buyer'' (Hagstrom, 1994, p. 51).

Furthermore, the willingness of banks to fund firms with possibly inefficient projects is greater, the larger the amount of collateral posted by these firms. Collateral effectively protects banks against the downside risk of the projects that they fund, thus increasing their incentives to lend. This is true irrespective of the source of inefficiency: optimism or managerial moral hazard. In contrast, the effect of collateral requirements on investment behavior does depend on the source of inefficiency. Empire builders will tend to reduce spending on grandiose but negative net-present-value projects if they are subject to punishment by the confiscation of collateral. But optimists believe their projects to be good and so will be relatively undeterred by increased collateral requirements, and the resulting lower interest rates may serve only to encourage them. This is why collateral requirements, which increase efficiency in other settings (see Section 4), may reduce efficiency in our context. Likewise, unlimited liability can lead to the same outcome, because both collateral and unlimited liability allow a bank to liquidate and appropriate the borrowers' assets only if there is a default, an event whose likelihood is bound to be underestimated by the overconfident entrepreneur. For these reasons, bankruptcy regulations that provide entrepreneurs with exemptions and the discharge of remaining debts, and so limit effective collateral and liability, tend to raise interest rates and discourage unrealistic optimism.

The above discussion raises the question of what is meant by market efficiency in an environment with agents who are not fully rational. We should not expect even a perfectly efficient market to protect agents against their own stupidity. Or should we? To elucidate this matter, we need to distinguish between two distinct origins of agent errors: those arising from an agent's preferences and those arising from his beliefs or perception. In the eyes of other persons, a given agent's preferences may appear to be inconsistent, immoral, or self-destructive: they may seemingly lead to actions not in that agent's own best interest. However, though preferences may be viewed as bad for their holder, it makes no sense to say that preferences are incorrect. Whether or not members of society ought to attempt to exercise paternalistic control over the actions of agents with questionable preferences is a difficult and controversial moral question (at least among noneconomists), and we will not discuss it further here.

However, because empirical evidence can be brought to bear on the accuracy of beliefs and perceptions, social intervention on behalf of agents who have untrue beliefs or incorrect perceptions has greater appeal in some quarters, and for that reason, one might wish to define a notion of economic efficiency in this context. Confusion arises here, though, because the preferences seemingly revealed by the actions of an agent with faulty perception diverge from his true underlying preferences. When market efficiency is defined in relation to true preferences, rather than in relation to "revealed preferences," even perfectly competitive markets may not be judged efficient. Indeed, in most free-market contexts, firms are prepared to exploit the perceptual errors and mistaken beliefs of potential customers, and corrective policy measures may appear to be warranted.[5] But this is not to say that well-intentioned paternalism is unknown in the free market. For instance, in market relationships characterized by repeat business, a seller may try hard to persuade a buyer to avoid what he considers to be unsuitable goods and services, lest the buyer blame the seller for poor or insufficient advice. In the model we analyze below, however, bankers (the relevant sellers in our model) have no incentive to be paternalistic and thus increase efficiency on their own.

[5] Even liberal philosophers, such as Feinberg (1986), agree that overriding an individual's choices may be warranted on the grounds that they are not truly voluntary when choice results from ignorance or mistaken belief, i.e., when these choices do not reflect the true underlying preferences. See also Trebilcock (1993) for a lengthier discussion on paternalistic interventions.

In Section 2 we present the static one-period version of our model. In Section 3 we convert the static model into a two-period dynamic model to analyze the dynamic incentives of the entrepreneurs. In Section 4 we attempt to position our model in the related literature and explore the rather different perspective it provides for various problems in corporate finance. Section 5 reviews policy implications of this research and presents our conclusions.

2. The static model

■ **Model framework.** Suppose there is one entrepreneur, who may be either a realist R or an optimist O, with probabilities μ and $1 - \mu$, respectively. And suppose that the entrepreneur is presented with an investment project of quality Q, where $Q = G$ (good) or $Q = B$ (bad) with probabilities γ and $1 - \gamma$. A project yields an output Y that depends both on Q and on the level of investment I, where $I = h$ (high) or $I = \ell$ (low). The output function $Y = Y(Q, I)$ is monotonically increasing in both arguments. In our discrete context this means that $Y(G, I) > Y(B, I)$ and that $Y(Q, h) > Y(Q, \ell)$.

The entrepreneur does not observe Q directly; rather he observes a quality signal $q = g, b$. A realist always observes a fully revealing signal, but an optimist always observes the good signal g whatever the underlying quality of the project, that is,

$$\Pr\{g \mid R, G\} = 1, \qquad \Pr\{b \mid R, B\} = 1, \quad \text{and} \quad \Pr\{g \mid O\} = 1. \tag{1}$$

The entrepreneur does not observe his own type. However, he always believes himself to be a realist, and he behaves the same way that a realist with that signal would behave.[6] Except for his possible optimism and the faulty perception it induces, the entrepreneur modelled here is a rational decision maker whose actions are aimed at maximizing his anticipated utility, who is forward-looking, and who understands the nature and implications of market interactions. In other words, we are concerned with a *near-rational* entrepreneur.

Based on the information embodied in his signal, the entrepreneur chooses the investment level I. It is assumed that the entrepreneur has no liquid assets available for investment, so that any investment must be financed by banks. In our simple framework, where the entrepreneur has no access to alternative investment projects, the size of the loan requested from the bank and the desired investment level must coincide.

Now suppose that there are a large number of banks, indexed by j, all facing a perfectly elastic supply curve for capital at an interest factor $\bar{r}$ (the interest rate plus one). The entrepreneur requests a loan of the size of his intended investment level I, and each bank responds with an offer of a loan at interest factor r_j and a collateral requirement c_j, where $c_j \leq r_j I$.[7] The entrepreneur chooses a bank $j = k$, posts the required collateral c_k, and borrows the amount I at the interest factor r_k. We restrict consideration to standard debt contracts with (outside) collateral: the entrepreneur is obligated to repay $r_k I$ at the end of the period; if he defaults on his payment obligations, then his outside collateral and his firm (inside collateral) are liquidated and the chosen bank appropriates the full liquidation value of both, up to a maximum of $r_k I$. Note that banks observe only the size of the loan requested and the size of the investment project;

[6] Our results would be robust to the generalization that the entrepreneur entertains the possibility that he is an optimist but attributes a probability to this event that is smaller than $1 - \mu$, the true probability.

[7] The stipulated forfeiture of borrowers' collateral in an amount greater than the repayment obligation would be treated as a penalty clause in U.S. contract law and would therefore be unenforceable. See Posner (1992).

they cannot observe the signal received by the entrepreneur, which is private information.

We assume that a bad project with a low level of investment and good projects at any level of investment are all creditworthy (that is, their returns exceed the social cost of funds), but that a bad project at a high level of investment is *never* creditworthy.[8] This implies

$$Y(G, \ell) > Y(B, \ell) > \bar{r}\ell, \qquad Y(G, h) > \bar{r}h, \quad \text{and} \quad Y(B, h) < \bar{r}h. \tag{2}$$

These assumptions turn out to be critical to the model, because a high investment in a bad project will necessarily lead to default, whereas high investments in good projects or low investments in projects of any type will not lead to default for interest factors sufficiently close to the cost of money.

Furthermore, we assume that as compared with the low investment, a high investment is cost-justified in good projects but not in bad projects. Letting ΔY_Q denote $Y(Q, h) - Y(Q, \ell)$, these statements imply that the following relationships hold:

$$\Delta Y_G > \bar{r}(h - \ell) > \Delta Y_B. \tag{3}$$

This, in turn, implies

$$Y(G, h) - \bar{r}h > Y(B, \ell) - \bar{r}\ell > 0, \tag{4}$$

that is, that good projects are more profitable than bad ones when both are operated at their optimal level of investment, though the profits in both cases are positive. This expresses the precise sense in which G projects are defined to be better than B projects.

In this section we develop a static model constructed as the one-shot signalling game represented in Figure 1. Here, one entrepreneur plays against the competitive banks. The type of the entrepreneur, unknown to all agents, need not be explicitly modelled in the game tree. However, statistical information about entrepreneur types is used when appropriate to calculate payoffs. The quality signal, known to the entrepreneur but not to the banks, is explicitly modelled and constitutes the relevant type within the game.

Note that every element of the game is well defined, and all common knowledge requirements are satisfied. From a game-theoretic perspective, the relevant payoff function for the entrepreneur is given by his anticipated payoff function, rather than by his actual payoff function as defined outside of the game. This is understood by the bank, so that the entrepreneur's game-theoretic payoff function is common knowledge. The banks' payoff functions incorporate the actual distribution of entrepreneurial psychological types. Inasmuch as the entrepreneur has full knowledge of this distribution (though not necessarily of his own psychological type), the banks' payoff functions are common knowledge as well.

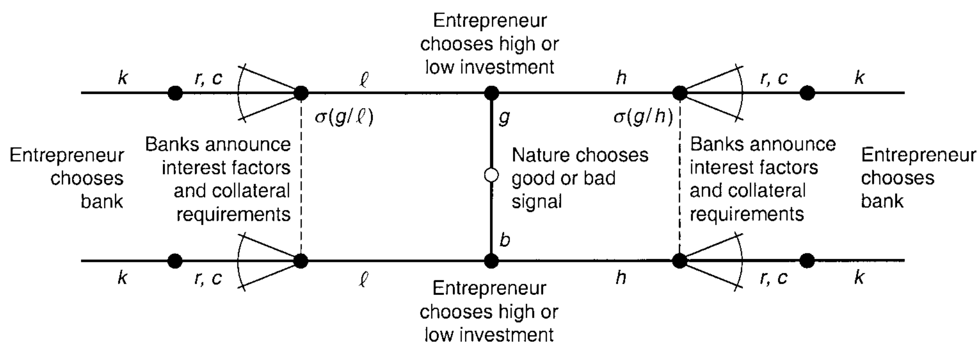
The sequence of play can be described as follows:

(i) Nature chooses a signal q, which is good (g) or bad (b) with probabilities ϕ and $1 - \phi$, respectively. It follows immediately from (1) that $\phi = \gamma + (1 - \mu)(1 - \gamma)$.

[8] The last assumption will imply that all pooling equilibria occur at the low investment level. This simplifies our model without diluting its message.

FIGURE 1

GAME



(ii) The entrepreneur responds to the signal by choosing an investment level I. The investment level I may be either low (ℓ) or high (h). To finance the desired investment, the entrepreneur applies for a loan of size I.

(iii) Each bank j observes the size of the loan I requested by the entrepreneur and forms a belief σ_j about the signal received by the entrepreneur. Based on the loan size and its beliefs, each bank announces an interest factor r_j and a collateral requirement c_j.

(iv) The entrepreneur chooses a bank k, posts collateral c_k, and borrows I from that bank.

In this game, the entrepreneur's strategy is given by his investment level (which equals the size of his requested loan) as a function of his quality signal and by his choice of a bank as a function of interest factors and collateral requirements, i.e., by a pair of functions $\{I = I(q),\ k = k(r, c)\}$, where $r = \{r_j\}$ and $c = \{c_j\}$ are the vectors of interest factors and collateral requirements offered by banks. The strategy of bank j is given by the interest function $r_j(I, \sigma_j(q|I))$ and the collateral-requirement function $c_j(I, \sigma_j(q|I))$, where σ_j is the probability distribution that describes the beliefs of bank j.

Each terminal node of the game is characterized by (q, I, r, c, k). Let $\pi(q, I, r, c, k)$ denote the payoff of the entrepreneur at the corresponding terminal node, and let $\pi_j(q, I, r, c, k)$ be the same for bank j.

Now, with the price of output normalized to one, we proceed to calculate the payoffs for the various possible outcomes of the game. We begin with the payoffs to the entrepreneur. Because the entrepreneur may make perceptual errors if he happens to be an optimist, his anticipated payoff and actual payoff will differ when the signal provides an incorrect indication of project quality. However, as explained before, his behavior will be determined entirely by his anticipated payoffs, which he fully believes to be correct. The existence of a discrepancy between his anticipated and actual payoffs is unknown to him. Because he believes himself to be a realist, he always interprets the signal received as a realist would do. Consequently, for game-theoretic purposes, the payoff of the entrepreneur is calculated as though he were a realist, whatever his true psychological type may be.

From (1) and Bayes' Law, it follows immediately that the entrepreneur evaluates the signal as perfectly revealing the true quality of the project, a fact represented by the statement that $\Pr\{G|g, R\} = \Pr\{B|b, R\} = 1$. Hence, the entrepreneur evaluates his payoff at each terminal node as

$$\pi(q, I, r, c, k) = \sum_{Q=G,B} \Pr\{Q|q, R\}\max\{Y(Q, I) - r_k I; -c_k\}, \tag{5}$$

where the collateral c_k represents the upper bound on the size of his possible losses.

We now turn our attention to the derivation of the payoff structure of the banks. All banks understand that the entrepreneur may be either a realist or an optimist, and they know the probabilities associated with each occurrence. Furthermore, they know the probabilities associated with project quality, and they understand the informational content of the signals. In the first instance, they will use this information to calculate the probability ρ that a project with signal g has quality G. This is given by

$$\rho = \Pr\{G|g\} = \frac{\gamma}{\gamma + (1 - \mu)(1 - \gamma)} < 1. \tag{6}$$

Similarly, banks can deduce that $\Pr\{B|b\} = 1$. Hence, the payoff of bank j at the terminal node (q, I, r, c, k) is given by the following:

$$\pi_j(g, I, r, c, k) \tag{7}$$
$$= \begin{cases} \rho \min\{r_k I, Y(G, I) + c_k\} + (1 - \rho)\min\{r_k I, Y(B, I) + c_k\} - \bar{r} I & \text{for } j = k, \\ 0 & \text{for } j \neq k; \end{cases}$$

and

$$\pi_j(b, I, r, c, k) = \begin{cases} \min\{r_k I, Y(B, I) + c_k\} - \bar{r} I & \text{for } j = k, \\ 0 & \text{for } j \neq k. \end{cases} \tag{8}$$

Inasmuch as the banks observe the size of loan requests but not the signal of the entrepreneur, they must use their beliefs about the signals, $\sigma(q|I)$, to evaluate their expected payoffs. These payoffs are given by

$$\Pi_j(I, r, c, k) = \sum_{q=g,b} \sigma_j(q|I)\pi_j(q, I, r, c, k). \tag{9}$$

As a solution concept for this game, we adopt the intuitive perfect Bayesian equilibrium (IPBE), that is, the perfect Bayesian equilibrium (PBE) with beliefs that satisfy the Cho-Kreps "intuitive criterion." Our PBE concept requires beliefs to be homogeneous among all banks and consistent with strategies and observed actions along the equilibrium path. The intuitive criterion restricts beliefs off the equilibrium path, which otherwise would be unconstrained.[9]

□ **Free-market equilibria with no collateral.** In this subsection we assume that collateral requirements (c) are constrained to be zero. We then search for separating and pooling equilibria.

A separating equilibrium is defined as an equilibrium in which the entrepreneur's strategy satisfies $I(g) = h$ and $I(b) = \ell$, i.e., the entrepreneur chooses the high level

[9] The set of IPBE of our signalling game coincides with the set of PBE of the corresponding screening game in which the banks offer the entrepreneur menus of contracts for loans of different sizes and allow the entrepreneur to then choose the loan size and bank simultaneously. This follows from the uniqueness of the IPBE for given parameter values. See Stiglitz and Weiss (1999).

of investment when he receives the good signal, and the low level of investment when he receives the bad one.

Under what conditions can a separating equilibrium occur in the case when collateral is constrained to zero for all banks? In the game without collateral, banks act as Bertrand competitors in interest factors alone. This implies that in equilibrium, the interest factor of the selected bank $r_k(I)$ must yield zero profits.

In a separating equilibrium, $I = \ell$ and $I = h$ imply that $q = b$ and $q = g$, respectively, so that if the equilibrium beliefs of banks are to be consistent with equilibrium actions, then we must have $\sigma(b|\ell) = \sigma(g|h) = 1$. Therefore, in the case of $I = \ell$ with $c \equiv 0$, equations (8) and (9) and Bertrand competition imply that the equilibrium interest factor $r_k(\ell)$ must satisfy

$$\min\{r_k\ell,\ Y(B,\ \ell)\} - \bar{r}\ell = 0. \tag{10}$$

Furthermore, our condition (2) tells us that $Y(B,\ \ell) > \bar{r}\ell$, so that $r_k(\ell) = \bar{r}$. Likewise, in the case of $I = h$ with $c \equiv 0$, equations (7) and (9) and Bertrand competition imply that the equilibrium interest factor $r_k(h)$ must satisfy

$$\rho \min\{r_k h,\ Y(G,\ h)\} + (1 - \rho)\min\{r_k h,\ Y(B,\ h)\} - \bar{r}h = 0, \tag{11}$$

which, by (2), has the solution

$$r_k(h) = \frac{\bar{r}}{\rho} - \frac{1 - \rho}{\rho}\frac{Y(B,\ h)}{h}, \tag{12}$$

provided that $Y(G,\ h) > r_k(h)h$, i.e., that the good project is profitable at the high level of investment for the actuarially fair interest factor. Otherwise, the banking industry will not finance h-level investments. Because the latter case is of little interest, we assume that the former case applies.

We can now determine when a separating strategy will be the entrepreneur's best response. Condition (2) implies that an entrepreneur with the b signal will always prefer the low investment, so that in any equilibrium $I(b) = \ell$. However, the investment choice of an entrepreneur with a g signal will depend on the interest factor $r_k(h)$. The necessary and sufficient condition for the existence of a separating equilibrium is that the anticipated payoff associated with $I(g) = h$ is at least as great as the payoff associated with $I(g) = \ell$, that is, $Y(G,\ h) - r_k(h)h \geq Y(G,\ \ell) - \bar{r}\ell$. Substituting (12) into this inequality yields the following proposition.

Proposition 1. In our banking game without collateral, a separating equilibrium exists if and only if

$$\Delta Y_G \geq \Delta C_1, \tag{13}$$

where ΔC_1, the incremental cost of borrowing h rather than ℓ, is given by

$$\Delta C_1 \equiv r_k(h)h - \bar{r}\ell = \frac{\bar{r}}{\rho}(h - \rho\ell) - \frac{1 - \rho}{\rho}Y(B,\ h). \tag{14}$$

This proposition simply states that a separating equilibrium exists in the market if and only if the difference in returns between the high and low levels of investment into the good project exceeds the difference in the equilibrium cost of funds.

In a pooling equilibrium $I(g) = I(b)$, and since we have already established that $I(b) = \ell$ in all equilibria, it follows that with pooling $I(g) = \ell$. Consequently, the adoption of a pooling strategy represents the collapse of the market for high-investment loans.

Condition (2) implies that whenever ℓ is invested in any project, that project must yield at least $\bar{r}\ell$, whatever its quality. Inasmuch as the investment in a pooling equilibrium must always be at the level ℓ, it follows that banks will always recover their own cost of funds whatever interest factor they set, even if the entrepreneur should default. Consequently, Bertrand competition will assure that $r_k(\ell) = \bar{r}$ in a pooling equilibrium.

Next we determine the interest factor $r_k(h)$ that banks would apply to a high-level loan h requested by a deviator. This, in turn, would depend on the banks' beliefs about the signal of the deviator. Suppose that an entrepreneur with a bad signal contemplates deviating and applying for the high-level loan. Believing that he is a realist (this time correctly), this entrepreneur will conclude that he has a bad project $Q = B$ with probability one. By (2), this implies that if he invests h he will default and earn payoff zero, whereas his payoff from investing ℓ must be positive. This means that his contemplated deviation is dominated by his equilibrium action.

But this is not the case for an entrepreneur who receives the good signal. Such an entrepreneur also believes himself to be a realist and thus believes that he has a good project with probability one. Therefore, a high level of investment would be cost-justified for interest factors sufficiently close to the social cost of funds $\bar{r}$, which immediately implies that the contemplated deviation is not dominated by the equilibrium action.

It follows that a belief that an entrepreneur with the b-signal would appear as such a deviator with positive probability would cause the corresponding pooling equilibrium to violate the intuitive criterion, so this will not be allowed for our purposes. Consequently, banks must believe that any deviator has a good signal, and Bertrand competition will yield the equilibrium interest factor given by (12). The necessary and sufficient condition for the existence of a pooling equilibrium is that the anticipated payoff associated with $I(g) = h$ is no greater than the payoff associated with $I(g) = \ell$, that is, $Y(G, h) - r_k(h)h \leq Y(G, \ell) - \bar{r}\ell$. Thus, a necessary and sufficient condition for pooling is equation (13) with the inequality reversed.

Proposition 2. In our banking game without collateral, a pooling equilibrium exists if and only if

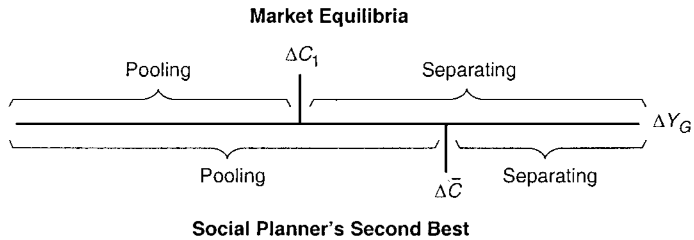
$$\Delta Y_G \leq \Delta C_1. \tag{15}$$

From Propositions 1 and 2, it follows that a separating equilibrium and a pooling equilibrium cannot coexist for the same parameter values unless $\Delta Y_G = \Delta C_1$. Hence, the value of the right-hand side of this equation divides the parameter space into two contiguous regions, one with investment pooling at the low investment level, and one with a separating outcome in which the entrepreneur with the good signal invests h and the entrepreneur with the bad signal invests ℓ. This is depicted in the top portion of Figure 2.

□ **Second-best social welfare.** It is immediately apparent from (3) that first-best social welfare is achieved when all good projects receive high investment levels and all bad projects low ones. But in our model, agents cannot observe the quality of the

FIGURE 2

POOLING AND SEPARATING IN REGIONS OF PARAMETER SPACE: MARKET EQUILIBRIA AND SOCIAL PLANNER'S SECOND BEST



individual project; the entrepreneur receives a signal that may or may not be accurate. Therefore, in this subsection we look for the second best. We ask what level of welfare could be achieved by a social planner whose access to information is given by the totality of what all agents themselves know. In this case, the social planner would have full information about the distribution of entrepreneurial types and project quality, and he would be able to observe the signal received by the entrepreneur but not his true psychological type. Subject to these informational constraints, the social planner would define a project investment function $I^*(q)$ that achieves the highest level of social welfare.

The crucial difference between the social planner and the entrepreneur in our model is that although both may have access only to limited information, the social planner, unlike the entrepreneur, is aware of this possibility. A fully rational entrepreneur, who understands that with probability $(1 - \mu)$ the informational value of his signal is limited, would behave just as our social planner does. Thus, the market outcome with a fully rational entrepreneur would coincide with our second best.

The social planner can set $I^*(q)$ either to separate the investment levels assigned to each of the two signals or to pool them by assigning the low level of investment to both signals.[10] In the former case, expected social welfare is given by

$$W_s = \gamma[Y(G, h) - \bar{r}h] + (1 - \mu)(1 - \gamma)[Y(B, h) - \bar{r}h] + \mu(1 - \gamma)[Y(B, \ell) - \bar{r}\ell], \tag{16}$$

where the first term is the probability-weighted surplus from good projects with good signals, the second term from bad projects with good signals, and the third term from bad projects with bad signals. (Good projects with bad signals never occur.) In the case that the social planner pools his investment levels, i.e., $I^*(q) = \ell$ for all q, the analogous expression is

$$W_p = \gamma[Y(G, \ell) - \bar{r}\ell] + (1 - \gamma)[Y(B, \ell) - \bar{r}\ell], \tag{17}$$

where the first term is the probability-weighted contribution of the good projects, and the second, of the bad projects.

We can now compare social surplus under pooling and separation. Moving from pooling to separation changes social surplus by $W_s - W_p$, as given by

[10] Pooling at the high level of investment makes no sense for the reasons described in the previous subsection.

$$W_s - W_p = \gamma[\Delta Y_G - \bar{r}(h - \ell)] + (1 - \mu)(1 - \gamma)[\Delta Y_B - \bar{r}(h - \ell)]. \tag{18}$$

The change from pooling to separation affects only the entrepreneur with a good signal. The first term of the right-hand side represents the expected change in social surplus from investing h rather than ℓ in a project with a good signal that turns out to be a good project. We know from (3) that this term is positive. The coefficient γ, here, represents the probability that the entrepreneur will have both a good project and a good signal. The second term represents the expected change in social surplus from investing h rather than ℓ in a project with a good signal that turns out to be bad. We know from (3) that this term is negative. The coefficient $(1 - \mu)(1 - \gamma)$ is the probability that the entrepreneur will have a good signal and a bad project.

The social planner would choose to separate the investments made for good and bad signals for parameter values that make $W_s - W_p > 0$, and he would choose to pool for parameter values that make $W_s - W_p < 0$. Hence, we have the following proposition.

Proposition 3. The socially optimal investment strategy is to assign the high level of investment to projects with the good signal, and the low level of investment to projects with the bad signal, whenever

$$\Delta Y_G \geq \Delta\overline{C}, \tag{19}$$

where

$$\Delta\overline{C} \equiv \frac{\bar{r}}{\rho}(h - \ell) - \frac{1 - \rho}{\rho}\Delta Y_B, \tag{20}$$

and where ρ, given by (6), is the probability that a good signal is associated with a good project.

From (14) and (20), we see that the difference between the social planner's switchpoint and the market switchpoint (see Figure 2) is

$$\Delta\overline{C} - \Delta C_1 = \frac{1 - \rho}{\rho}[Y(B, \ell) - \bar{r}\ell] > 0. \tag{21}$$

Note that the range of parameter values for which market outcomes are inefficient is increasing in $(1 - \mu)$, and it becomes zero when $\mu = 1$.

Therefore, we have the following proposition.

Proposition 4. For the range of parameter values described by $\Delta C_1 < \Delta Y_G < \Delta\overline{C}$, the market assigns the high level of investment to projects with the good signal and the low level of investment to projects with the bad signal, even though social optimality would require the low level of investment for all projects, irrespective of the signal received.

Thus, when some bank clients are optimists, the loan market may turn out not to be sufficiently conservative. The optimistic entrepreneur attributes a zero probability to having a bad project, and when he has one, he may use it incorrectly by investing h into it. This leads to two distinct types of social losses. First, his large investment is socially unjustified, since $Y(B, h)$ is smaller than $\bar{r}h$, the social cost of capital. Society would have been better off had the project been left entirely undone. The expected social loss from this error is $[(1 - \rho/\rho)][\bar{r}h - Y(B, h)]$. However, because competitive banks adjust their interest rates accordingly, this cost is internalized in the decision making of the entrepreneur.

In addition, there is a second opportunity cost to the entrepreneur's improper investment decision: society has forgone the surplus associated with putting the bad project to its appropriate use by investing ℓ. The expected size of this loss is $[(1 - \rho/\rho)][Y(B, \ell) - \bar{r}\ell]$. This opportunity cost does not put banks at risk, because it is internalized entirely by the entrepreneur. Thus, this cost is not reflected in the competitive interest rate, and since the optimistic entrepreneur is not aware of its existence, it will not be internalized in his decision making. But the social planner must take this cost into consideration, and it is this opportunity cost that explains the divergence between market and planner. This divergence will extend to the case where the optimistic entrepreneur attributes a probability less than $1 - \mu$ to being an optimist.

It is important to understand that the inefficiency described here arises because of the faulty perception of the optimistic entrepreneur and the competitive market structure of the banking industry, not because of the restricted nature of the standard debt contract. The entrepreneur, who as residual claimant has the incentive to create a surplus from the ℓ-level investment, lacks the knowledge of its probabilistic existence, while the banks, who have that knowledge, cannot act on it because of competition. Even contracts that shift control rights over investment from the entrepreneur to the bank would not change this underlying reality.

□ **Free-market equilibria with collateral.** Suppose, now, that banks are permitted to require the posting of collateral, and suppose that the entrepreneur has the ability to post collateral sufficient to cover his entire indebtedness if he is required to do so. In the event of default, the bank can liquidate the investment project and the posted collateral, but only up to the full value of the repayment obligation. Therefore, the repayment in the event of default will be

$$\min\{r_j(I)I,\ Y(Q, I) + c_j(I)\}. \tag{22}$$

Now we show the following.

Proposition 5. When banks are free to require full collateral, there is a unique equilibrium outcome, which has the following characteristics:

(i) the entrepreneur uses a separating investment strategy: $I(g) = h$, $I(b) = \ell$;

(ii) the interest factors announced by the chosen bank are equal to the social cost of funds: $r_k(h) = r_k(\ell) = \bar{r}$; and

(iii) the chosen bank requires full collateral for the large loan: $c_k(h) = \bar{r}h - Y(B, h)$.

Proof. First let us analyze the case of loans of size ℓ. We know from (8) that for these loans, banks recover at least $Y(B, \ell)$, even without resorting to collateral. But by (2), this amount must strictly exceed $\bar{r}\ell$. Thus if the chosen bank were to lend ℓ at a rate $r_k > \bar{r}$, that bank would earn a positive profit. Betrand competition immediately implies that in any equilibrium $r_k(\ell) = \bar{r}$, and it follows that the entrepreneur will fully repay his debt with probability one and have positive profits remaining. Consequently, in the case of the small loan, banks would never have occasion to liquidate posted collateral, so both the banks and the entrepreneur will be indifferent to its amount.

Furthermore, the guarantee of positive entrepreneurial profits from investment ℓ implies that in equilibrium, the entrepreneur will not borrow and invest h unless he anticipates positive profits at that level as well, which in the context of our discrete model implies that he anticipates a zero probability of default. Because collateral is liquidated only in the default state, this means that if the entrepreneur invests h in equilibrium, his anticipated payoff must be independent of the amount of collateral $c_k(h)$ the chosen bank requires, so that the entrepreneur will choose a bank posting the lowest interest factor $r_k(h) = \min_j\{r_j(h)\}$. In equilibrium, banks must believe that an entrepreneur who requests a loan of size h has the good signal g, and they know there is a probability $1 - \rho$ that the entrepreneur has bad projects that will fail. Thus, payoffs to the chosen bank must increase with $c_k(h)$.

Suppose that in equilibrium, the chosen bank has an interest factor $r_k(h) > \bar{r}$ and requires collateral $c_k(h) < r_k(h)h - Y(B, h)$. Then, a deviation that increases the collateral requirement would increase the bank's payoffs provided only that the entrepreneur continues to patronize the bank. But for any increase in collateral, there exists a sufficiently small reduction in the interest factor that would ensure continued patronage while leaving payoffs of both parties above the original level. Therefore, the postulated debt contract is not consistent with equilibrium.

So, suppose on the one hand that the chosen bank has an interest factor $r_k(h) > \bar{r}$ and requires collateral $c_k(h) = r_k(h)h - Y(B, h)$. Then the bank will be fully repaid even when the entrepreneur defaults, so that with $r_k(h) > \bar{r}$ the bank is assured a positive profit, and other banks could deviate and undercut the chosen bank. If, on the other hand, the chosen bank sets $r_k(h) \le \bar{r}$ and $c_k(h) < r_k(h)h - Y(B, h)$, then the bank will earn negative profits and would then deviate.

If an equilibrium exists, it must be true that $r_k(h) = \bar{r}$ and $c_k(h) = r_k(h)h - Y(B, h)$ for the chosen bank. But, clearly, such an equilibrium does exist, for if the chosen bank sets $r_k(h)$ and $c_k(h)$ as above, and one other bank j sets $r_j(h) = \bar{r}$, then no deviation is profitable. Assertions (ii) and (iii) above are proved; assertion (i) follows immediately from (3). *Q.E.D.*

The main result of this section is summarized by the following proposition, which is derived directly from Propositions 3 and 5.

Proposition 6. In the absence of collateral requirements, the market sometimes yields an outcome with pooling, which is always socially efficient when it occurs. When full collateral requirements are permitted, the market never yields pooling, even when pooling would be socially efficient. Hence, collateral sometimes reduces market efficiency but never increases it.

This result is contrary to the spirit of most existing results on collateral in the literature. In Bester (1985) and in many other articles, collateral requirements play the role of limiting adverse selection and moral hazard. Loan applicants who accept collateral requirements are forced to internalize the costs of their own activities; those who do not accept those requirements can be separated as bad risks and treated accordingly.

In our model, however, collateral cannot be used to separate the optimists from the realists, for the former believe themselves to be realists and are willing to accept whatever requirements the realists would accept. Collateral does serve to protect the banks from the errors of the optimists, but in their competitive framework this reduces the cost of capital for entrepreneurs, which further encourages the optimists, who are overactive even without such encouragement. The same intuition applies to *unlimited liability,* which also protects banks from defaulting loans but which, by reducing the equilibrium cost of capital, further encourages overconfident entrepreneurs and thus reduces the efficiency of the credit market.

The result that optimistic entrepreneurs are willing to fully collateralize their loans does not extend to a scenario with nondeterministic investment outcomes. Whenever there is a positive probability of failure, the posting of collateral becomes costly to the entrepreneur. However, the optimistic entrepreneur underestimates the probability of default and so underestimates the cost of collateral as well. Consequently, the qualitative inefficiency result of Proposition 6 is maintained.

3. Dynamic model

■ **Dynamic framework.** In this section we consider a dynamic model, constructed as a modified two-period version of the static model. For the moment, we assume that collateral requirements are constrained to zero. The dynamic model differs qualitatively from the static model, because banks can use first-period information to make inferences about the psychological type of the entrepreneur and then use those inferences in setting interest rates for the second period. It follows that the entrepreneur has an incentive to signal his perceived psychological type (i.e., that he is a realist) through his investment choice in period 1. This incentive may make the entrepreneur act more conservatively in the first period of the dynamic model than he did in the static model. In fact, he may turn out to be even more conservative than the social planner would be.

Model parameters are the same as in the static model. In the dynamic model, however, the investment strategy space of the entrepreneur is generalized to permit randomization between the low and high investment levels, ℓ and h. In fact, we will show that for certain parameter combinations, the unique equilibrium is characterized by such mixed strategies. Let x define the probability that an entrepreneur with a good signal g invests at the level h, and let y be the corresponding probability for an entrepreneur with a bad signal b. In Appendix A we show that in any equilibrium $y = 0$, so in what follows x will be the only variable of interest.

The sequence of events is as follows: period 1 unfolds as described in Figure 1, except that after observing g, the entrepreneur chooses h with probability $x \in [0, 1]$ and ℓ with probability $1 - x$. As before, banks observe h or ℓ and set their interest factors, r, accordingly. At the end of period 1, the entrepreneur either succeeds and fully repays the bank, or he fails and defaults. Default leads immediately to bankruptcy and discharge of debts, so that by the end of the first period, all existing debt has been either repaid or cancelled. In this model, optimists with bad projects and high investments always fail, but there are no failures in other circumstances. The level of investment and the ensuing success or failure in period 1 are observed by both the entrepreneur and the banks; and both may use this information subsequently.

In period 2, the entrepreneur is presented with another project, whose quality is random and independent of that of period 1.[11] The independence of project quality is consistent with the idea that a good project is a manifestation of good luck rather than of the ability of the entrepreneur, all of whom are identical in this regard.[12] For simplicity, we shall assume that the entrepreneur continues to believe he is a realist, even

[11] The lack of correlation of project quality across periods does not imply that inferences about psychological type cannot be made from outcomes in our model. Although the interest rate charged does not decline after success with a large loan, failure reveals an optimist (to the bank) and will cause the interest rate to rise.

[12] Correlation of project quality would cut both ways. Entrepreneurs with a good signal in the first period would expect to have a good project in the second and therefore would have a stronger incentive to signal their realism by borrowing ℓ. But banks would infer an increased probability of a good project in the second period from success with an h-loan in the first period, and this would lessen the entrepreneur's desire to signal.

if he defaults at the end of period 1,[13] but because the entrepreneur in period 1 anticipates a zero probability of default, this assumption does not affect the primary results of the model, which relate to decisions of the first period. As in period 1, the entrepreneur in period 2 cannot observe the quality of this new project directly, but he observes a quality signal whose relation to actual quality is described by equation (1). The entrepreneur responds to the signal by choosing an investment level, h or ℓ (except for one point of parameter space, he would never choose to randomize in period 2). Each bank observes the entrepreneur's credit history (his first-period investment level and performance) and current loan request and uses this information to form its beliefs about the identity of the entrepreneur and his signal. These beliefs, in turn, determine the bank's interest factor. As in the static model, the game-theoretic payoff functions of both entrepreneur and banks are common knowledge.

We proceed to characterize the market equilibria of our dynamic game.

□ **Market equilibrium and efficiency in period 2.** At the time that banks set interest rates in period 2, they can observe one of the following credit histories from the previous period:

(i) high investment, full repayment: $\langle h, s\rangle$;
(ii) high investment, default: $\langle h, n\rangle$; and
(iii) low investment, $\langle \ell \rangle$, which is fully repaid in any equilibrium.

Entrepreneurs with the credit history $\langle h, s\rangle$ are exactly those who had good projects in the first period, so that each such entrepreneur is a realist with probability μ, as in the static model. Thus, he will face the static model's interest factors for high- and low-level loans, and the conditions for separation and pooling with respect to the good and bad signals are also the same.

Entrepreneurs with the credit history $\langle h, n\rangle$ are optimists who had bad projects in the first period, and they are revealed to the banks as such. Equilibrium interest factors will be set accordingly. Because the entrepreneur, realist or optimist, expects to succeed in period 1 with probability one, the payoff of the continuation game with this credit history is not used by the entrepreneur in his first-period calculations.

Entrepreneurs with the credit history $\langle \ell \rangle$ are realists who had bad projects in the first period, plus those entrepreneurs with g-signals who chose to borrow ℓ in order to signal realism to bankers. The more entrepreneurs in the latter group (i.e., the smaller is x), the less that signal will be worth. Straightforward but lengthy calculations[14] show that $r_k(h|\langle \ell \rangle, x)$, the interest factor charged for large loans to those with credit history $\langle \ell \rangle$, falls from $r_k(h)$ when $x = 0$ to $\bar{r}$ when $x = 1$. It follows that in period 2, for the entrepreneur with credit history $\langle \ell \rangle$, the incremental cost of choosing h rather than ℓ is no greater than the corresponding cost in the static model. We can now assert that parameters that lead to separation in the static model will lead to separation in period 2 of the dynamic model whatever the credit history happens to be.

Note that from the efficiency point of view, the second period of our dynamic model is qualitatively the same as our static model. For each credit history, the second

[13] Many of us academic economists seem to feel that it is unreasonable to assume the perseverance of erroneous beliefs in the face of contrary evidence. This is in spite of our own obvious reluctance to give up cherished economic notions long after they are shown to have been entirely unfounded. In their article on the psychology of attribution, Ross and Anderson (1982, p. 144) note: ''It appears that beliefs—from relatively narrow personal impressions to broader social theories—are remarkably resilient in the face of empirical challenges that seem logically devastating.''

[14] For the sake of brevity and readability, we omit most mathematical calculations from this section. A supplement with complete mathematical details is available at http://econ.bu.edu/manove/bank_abs.htm.

period of the dynamic model is isomorphic to our static model, but with a possibly different value of μ. This means that in the second period, the market is always insufficiently conservative, except for the credit history $\langle \ell \rangle$ with $x = 1$. In that case, the entrepreneur with $\langle \ell \rangle$ is known to be a realist and the market is efficient.

□ **Market equilibrium in period 1.** In period 1 of the dynamic model, banks will set the same equilibrium interest factors as in the static model. The reason is twofold. First, because of perfect competition, banks will earn zero profits in the period-2 continuation game regardless of their current pricing decisions. Consequently, banks set interest factors in period 1 to maximize current profits. Second, the entrepreneur's strategy x affects the realist with the good signal and the optimist in the same way. For any $x > 0$, the probability of repayment of the high-level loan h and thus the equilibrium beliefs of banks in period 1 are the same as in the static model. For $x = 0$, the equilibrium beliefs of banks must coincide with those of the pooling equilibrium of the static model if the intuitive criterion is to be satisfied. As in the static model, the interest factor for loan ℓ must be $\bar{r}$.

We proceed to characterize the first-period investment choice of the entrepreneur with the g-signal for different regions of the parameter space.[15] First we consider the range of parameters associated with pooling in the static model, that is, the range given by $\Delta Y_G < \Delta C_1$. Note that the effect of changing from h to ℓ in period 1 on the second-period payoffs of the entrepreneur must be nonnegative, inasmuch as interest factors associated with the credit history $\langle \ell \rangle$ can be no higher than those associated with $\langle h, s \rangle$. This means that dynamic considerations always increase the incentive to pool in the first period. Consequently, any parameters that lead to pooling in the static model must also lead to pooling in the first period of the dynamic model; for those parameters the entrepreneur will set $x = 0$. But in this case, the second-period interest factors applied to the credit history $\langle \ell \rangle$ coincide with those of the static model, so that there will also be pooling in period 2.

So far we know the following: if $\Delta Y_G < \Delta C_1$ (pooling in the static model), we have pooling in both periods of the dynamic model; if $\Delta Y_G > \Delta C_1$ (separation in the static model), we have separation in the second period of the dynamic model, whatever the credit history. It remains only to analyze the entrepreneur's first-period investment choice whenever $\Delta Y_G > \Delta C_1$.

Let ΔC_2 denote the maximum two-period incremental cost of choosing h rather than ℓ in the first period, which occurs when $x = 1$, and suppose now that $\Delta Y_G > \Delta C_2$. It is not difficult to show that for entrepreneurs with the g-signal, h strictly dominates ℓ in the first period whenever $x < 1$; furthermore, h is a best response when $x = 1$. Therefore, $x = 1$ constitutes the unique equilibrium action for the entrepreneur in period 1, and we can conclude that there is a unique equilibrium for parameters in this range. This is a separating equilibrium with respect to good and bad signals in each of the two periods.

Next, suppose that $\Delta C_1 < \Delta Y_G < \Delta C_2$, and let $\tilde{x}$ be defined by

$$\tilde{x} = \frac{\rho(\Delta Y_G - \Delta C_1)}{\gamma \Delta Y_G + (\rho - \gamma)\Delta C_2 - \rho \Delta C_1}. \tag{23}$$

The variable $\tilde{x}$ is a strictly concave function of ΔY_G, and its value goes from zero to

[15] Note that both the realistic entrepreneur with a g-signal and the optimistic entrepreneur anticipate that they have only the probability γ of receiving the good signal in the second period. However, the optimist, unbeknown to himself, will receive the good signal with probability one, and once that occurs, he will believe that he is a realist fortunate enough to have drawn the good project.

one as ΔY_G goes from ΔC_1 to ΔC_2. One can demonstrate that h dominates ℓ when $x < \tilde{x}$, so that an entrepreneur's best response is $x = 1$, and that ℓ dominates h when $x > \tilde{x}$, so that an entrepreneur's best response is $x = 0$. Furthermore, the net payoffs for h and ℓ are equal when $x = \tilde{x}$, so that every value of x is a best response for the entrepreneur. We can conclude that $x = \tilde{x}$ constitutes the unique equilibrium action for the entrepreneur in period 1 for parameters in this range. Therefore, for a given set of parameters in the range specified by $\Delta C_1 < \Delta Y_G < \Delta C_2$, there must exist a unique equilibrium, one that features partial pooling in the first period to an extent given by $\tilde{x}$.

To understand the model solution in this parameter range, suppose that ΔY_G is slightly greater than ΔC_1. In the static model, this would lead to a separating equilibrium, but in the first period of the dynamic model, the entrepreneur would have the incentive to deviate by investing at the level ℓ in order to signal that he is a realist. However, this situation would not be compatible with a pooling equilibrium, because then the choice of ℓ would have lost its signalling value, and the entrepreneur facing these parameters would want to deviate by separating. But pooling with a positive probability less than one, provides a mixed-strategy equilibrium. As the probability of pooling increases, the value of the signal decreases. Consequently, the equilibrium would occur at exactly that probability of pooling for which the signalling value of choosing ℓ precisely offsets the incentive to separate created by the difference between ΔY_G and ΔC_1.

We have demonstrated the following proposition.

Proposition 7. For any parameter values, the dynamic model has a unique intuitive perfect Bayesian equilibrium. Behavior of the entrepreneur in the first period is given by

$$x = \begin{cases} 0 & \text{for } \Delta Y_G \leq \Delta C_1, \\ \tilde{x} & \text{for } \Delta C_1 < \Delta Y_G < \Delta C_2, \\ 1 & \text{for } \Delta Y_G \geq \Delta C_2. \end{cases} \tag{24}$$

Note that the qualitative results of our dynamic model would remain unchanged if the project quality and the signal space were modelled as continuous variables. Consider an alternative model in which $\Gamma(Q)$ denotes the probability that the true project quality takes a value smaller than or equal to Q, and suppose that when quality $\hat{Q}$ is realized, the signal observed by a realist is $q_r = \hat{Q}$ and the signal observed by an optimist is $q_o = \omega\hat{Q}$, with $\omega > 1$. Suppose, further, that the optimal investment for a project of quality Q is $I(Q) = Q$. Under these assumptions, the distribution of signals observed by optimists would first-order stochastically dominate the distribution of signals observed by realists. This means that the probability of being an optimist conditional on signal size is increasing in the signal size. Consequently, in equilibrium, the entrepreneur would have an incentive to distort his investment-loan request downward. This is because a downward shift from the perceived optimal investment level entails a second-order loss in market revenues but a first-order reduction in the cost of capital.

□ **Efficiency in period 1.** As in the static model, we assume the existence of a social planner with access to the pooled information of all agents but not to direct knowledge of the entrepreneur's psychological type or the quality of his project. The social planner solves the problem of choosing the level of investment to be assigned to the project in each period; his strategy is a function that assigns a level of investment to each information set. The dynamic structure of the planner's problem is described as a tree in

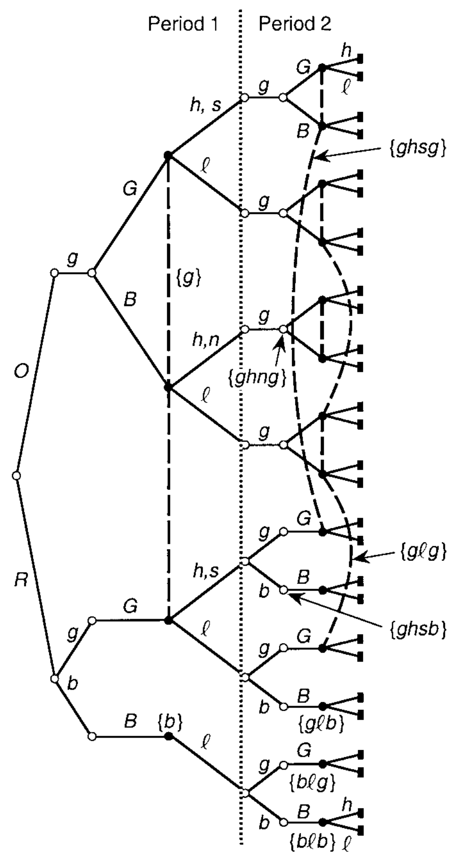
Figure 3. As before, we use the term "second-best" to describe the solution to this planner's problem.

At the outset, we note that if the social planner observes the receipt of a *b*-signal in the first period, he knows immediately that the entrepreneur is a realist. This fact is not of interest in the static model, because the ℓ-investment would be assigned to an entrepreneur with a *b*-signal without consideration of the psychological type. But in the dynamic model, this information can be applied whenever an entrepreneur receives a *g*-signal in period 2. In that event, the planner would assign the high-level investment to the entrepreneur in the second period. Because banks observe the requested loan but not the underlying quality signal received by the entrepreneur, banks can never single out the realistic entrepreneur for special treatment, except in that parameter range in which there is total separation in period 1. Thus, for parameters that do not produce total separation in the first period, the market cannot hope to achieve second-best efficiency in the expected-value sense.

In Appendix B we use backward induction to formally analyze the social planner's decision in period 1. Here, we proceed to compare the market outcome in period 1 with the second-best outcome. It turns out that in period 1 the social planner's switchpoint between separating and pooling is the same as in the static model, so that in period 1, the difference between the social planner's switchpoint and that of the market is

FIGURE 3

PLANNER'S DYNAMIC GAME



$$\Delta\overline{C} - \Delta C_2 = (\Delta\overline{C} - \Delta C_1) - \frac{1-\rho}{\rho}\gamma[\overline{r}h - Y(B, h)]. \qquad (25)$$

The first term reflects the element of static inefficiency associated with the insufficient conservatism of market outcomes. The second term, instead, reflects the dynamic inefficiency created by the entrepreneur's incentive to signal that he is a realist, a form of rent seeking that arises in the dynamic model. In contrast to the first effect, the signalling effect tends to make the behavior of the entrepreneur and therefore the market more conservative, perhaps excessively conservative. Whether the market is excessively or insufficiently conservative in period 1 is determined by the relative size of these two effects.

Proposition 8. If $\Delta C_2 < \Delta\overline{C}$, then, as in the static model, the market is insufficiently conservative for the range of parameter values, $\Delta C_1 < \Delta Y_G < \Delta\overline{C}$, though in the range $\Delta C_1 < \Delta Y_G < \Delta C_2$ the divergence between the actions of the market and social planner is moderated as compared with the static model. If $\Delta C_2 > \Delta\overline{C}$, then the market is insufficiently conservative for the range of parameter values, $\Delta C_1 < \Delta Y_G < \Delta\overline{C}$, but it is excessively conservative in the range, $\Delta\overline{C} < \Delta Y_G < \Delta C_2$. In the second period, the market may be insufficiently conservative but never excessively conservative.

So far, our analysis of the dynamic model has presupposed that collateral is constrained to zero. However, as in the static model, full collateralization would be the equilibrium outcome if collateral was permitted and was available to the entrepreneur. Furthermore, with full collateral, all bank interest factors in both periods would be set to the social cost of funds $\overline{r}$. For this reason, there would be no incentive for the entrepreneur to signal that he is a realist. Therefore, when full collateral is permitted, the results in each period of the dynamic model would exactly duplicate the results of the static model.[16]

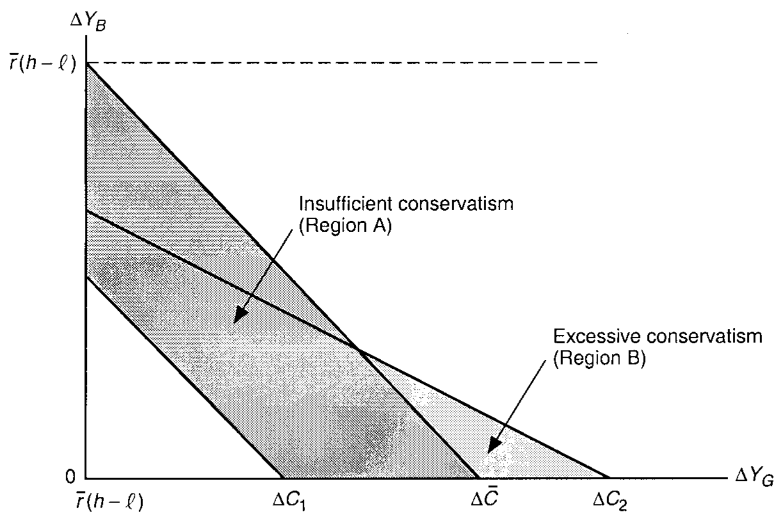
For the first period of the dynamic model, Figure 4 summarizes the nature of the inefficiencies that characterize the credit market in the presence of optimistic entrepreneurs. In region A of the figure, the second best requires pooling, which the market fails to yield in the absence of regulation. The problem is that too many bad projects receive a high level of investment. All of these bad projects are proposed by optimistic entrepreneurs, who perceive them as good projects. Given their perceptions, these optimists behave exactly as realists do, so that there is no way to induce them to invest ℓ instead of h without inducing all entrepreneurs with good projects (both realists and optimists) to invest ℓ as well. This limitation prevents regulators from achieving the first-best outcome, though they have many tools at their disposal for achieving the second-best outcome.

In region B of Figure 4, the second best requires separation but the market yields pooling; that is, too many good projects receive a low level of investment. This is the effect caused by the propensity of entrepreneurs to signal that they are realists by pursuing a conservative investment strategy. Note that such signalling behavior will arise only under limited circumstances. Two separate conditions must prevail: (1) conservative investment behavior must be an effective signal of realism, and (2) the future value of separating from optimists must exceed the immediate loss caused by substituting the low investment for the high one. These conditions will hold only if most

[16] Yet, in practice, bankruptcy law, contract law, and wealth limitations restrict the amount of collateral, so that loans are far from being fully secured. Also, the liquidation of collateral is costly. For these two reasons, interest rates will depend on project size, and this gives rise to the signalling incentives discussed above.

FIGURE 4

INSUFFICIENT AND EXCESSIVE CONSERVATISM IN THE FIRST PERIOD OF THE DYNAMIC MODEL



entrepreneurs with the good signal are investing h and if interest-rate differentials between optimists and realists in future periods are high and can operate for a sufficiently long time. Furthermore, measures that reduce interest-rate differentials, such as the posting of collateral, will diminish the incentive to signal and thus decrease the area in region B of Figure 4.

4. Related literature

■ This article is connected with several different strands of the banking and finance literature. Most obviously, our model shares a number of characteristics with the now standard adverse-selection credit-market model (see Stiglitz and Weiss (1981)). In the adverse-selection story, entrepreneurs have access to projects of different quality, and project quality is private information of entrepreneurs. Here ‘‘bad projects’’ are riskier projects, rather than ‘‘small’’ projects as in this article. But both models suggest that in equilibrium, either too many bad projects are financed or not even good projects are financed (market collapse). Moreover, both models imply important pecuniary transfers across entrepreneurial types.

There are important differences, however. In adverse-selection models, entrepreneurs know when they have risky projects, and they will act only if their own wealth is sufficiently shielded from the consequences of failure. So lenders can discriminate between entrepreneurs with projects of different qualities by offering a menu of contracts comprising various interest-rate and collateral-requirement combinations (see, for instance, Bester (1985), Besanko and Thakor (1987a, 1987b), and Chan and Thakor (1987)). But unlimited liability and collateral requirements serve only to exacerbate the problems created by optimistic entrepreneurs. These problems are particularly difficult to solve contractually because optimists, by definition, are not conscious of their own biases. Some form of paternalistic coercion, such as the introduction of a nonwaivable right of discharge in bankruptcy law, is required in our scenario.

The problem of entrepreneurial optimism is also related to certain types of agency problems, most especially to those commonly referred to as empire building. In empire-building models (as in Hart, 1995), managers receive private benefits from building corporate empires. Like optimistic entrepreneurs, these managers may take on negative net-present-value projects, but unlike optimists they do so intentionally and with the comforting knowledge that they are spending someone else's money. If things go wrong, their wealth is protected by limited liability. Again, these problems can be mitigated with contracts that force managers to pay more for their mistakes.[17] As we know, this is not true when entrepreneurs are optimists.

It is true, however, that both empire-building models and our model of entrepreneurial optimism could provide a basis for the so-called free-cash-flow problem. Jensen (1986) argued that free cash flow, defined as ''cash flow in excess of that required to fund all projects that have positive net present values when discounted at the relevant cost of capital'' (p. 323), is dangerous to a firm, because it allows opportunistic managers to undertake unjustified investments. Our model suggests that free cash flow may lead to inefficient investments even in the absence of agency problems, if entrepreneurs entertain optimistic expectations. But whereas there is ample evidence that entrepreneurs and other individuals tend to overestimate their chances of success, Heaton (1997) notes that ''virtually no evidence exists that managers *knowingly* engage in value-destroying project selection'' (p. 4).

There is a growing number of theoretical contributions that analyze the performance of markets characterized by a mixture of rational and near-rational decision makers. Much of this work can be placed in the emerging field of behavioral finance (see De Bondt and Thaler (1995) and Thaler (1993) for excellent surveys of recent contributions). An important conclusion from these studies is that nonrational agents are important to market outcomes, with exceptions only in special circumstances. For instance, DeLong et al. (1990, 1991) show that optimistic noise-traders may coexist with rational traders in a competitive stock market, which proves that divergence of price from intrinsic value does not necessarily create an arbitrage opportunity. Likewise, Manove (1998) demonstrates that in some technological environments, optimistic entrepreneurs may coexist with rational entrepreneurs in competitive equilibria or even drive them out of business.[18] Furthermore, the resulting competitive equilibria will exhibit significant distortions. A similar point is made by Akerlof and Yellen (1985), who show that when rational and near-rational agents (characterized by slight inertia) coexist, the equilibrium can differ substantially from that of all rational agents.

Our article is in the spirit of those recent contributions in behavioral finance that focus on the implications of entrepreneurial and managerial overconfidence for financial markets. For instance, Roll (1986) offers the ''hubris'' hypothesis to a curious phenomenon connected to corporate takeovers: although the target firm's stock price rises significantly when the company is purchased, the stock price of the acquiring firm does not tend to be positively affected. Roll suggests that the managers of the acquiring firm may be overconfident because of previous successes that were possibly the result of good luck. These managers wrongly conclude that they will be able to improve the operating earnings of the target firm. Ritter (1991) finds that IPOs are overpriced over the long term and explains this curious phenomenon by suggesting that investors are periodically overoptimistic about the future of young companies, a bias that firms can and do exploit.

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[17] Collateral requirements can help resolve a number of moral hazard problems, such as asset substitution, inadequate effort supply, and underinvestment (see, among others, Myers (1977), Smith and Warner (1979), and Stulz and Johnson (1985)).

[18] Articles on entrepreneurial optimism implicitly raise the question of why we might expect optimists to persist in financial markets, in the economy, and in the population at large. In addition to Manove (1998) and De Long et al. (1990, 1991), mentioned above, Bernardo and Welch (1997), Kyle and Wang (1997), and Waldman (1994) tackle this question from either an economic or an evolutionary perspective.

Other puzzling stock-market regularities, such as underreaction and overreaction of stock prices to new information, are explored in Barberis, Schleifer, and Vishny (1998) and Daniel, Hirshleifer, and Subrahmanyam (1998). Wang (forthcoming), Odean (1998), and Hirshleifer, Subrahmanyam, and Titman (1994) examine the implications of investor overconfidence in securities markets. Also, Ausubel (1991) explains the seemingly noncompetitive levels of finance charges in the credit-card market (a market with over 4,000 issuing banks) as the result of overoptimistic customers, who select credit cards under the assumption that they will always repay the balance before interest charges accrue, even though the objective statistics show that they do not.

Our article builds on the novel work of de Meza and Southey (1996), who explore the credit-market problems of excessively optimistic entrepreneurs. Unlike de Meza and Southey, however, we are concerned primarily with the information problem faced by banks, which cannot readily differentiate optimists from other agents. It is this feature of asymmetric information that connects the fate of realists and optimists in the credit market and undermines efficiency for all agents.

This article is also related to Heaton (1997) and Gromb, Manove, and Padilla (1997), who study the corporate-finance implications of the presence of optimistic managers. One could argue that it is more appealing to focus on overconfident managers and entrepreneurs than on overconfident stock-market investors, because the latter are likely to have their funds arbitraged away fairly rapidly.

5. Conclusion

■ It is widely thought that the credit market is overly conservative, because banks frequently withhold credit from worthy entrepreneurs. In this article we have developed a formal argument to show that the opposite may well be true. Our theory is based on the existence of optimistic entrepreneurs who are overconfident about the range of applicability of their investment projects. We show that in the presence of optimists, perfectly competitive banks may be insufficiently conservative in their dealings with entrepreneurs, despite the fact that entrepreneurs themselves may practice self-restraint to signal realism and thus benefit from reduced interest rates in the future. We have also shown that contrary to conventional wisdom, the use of collateral requirements by banks may reduce the efficiency of the credit market. This is because in a perfectly competitive market collateral requirements lower the cost of capital, which further encourages bold investment choices, particularly among optimistic entrepreneurs who tend to underestimate the probability of default and so to undervalue the cost of collateral.

These results have policy implications. Conservative bank lending policies may well be justified, even in the face of pronounced criticism from the small-business community. Furthermore, bank examiners ought to be concerned about risky loans, especially when banks are protected by posted collateral and so have little private incentive to screen proposals carefully.

Finally, our analysis has significant implications for personal bankruptcy regulation. In the Middle Ages, many nations had bankruptcy rules that permitted the creditor to claim all assets of the debtor, right up to the pound of flesh. Over time, bankruptcy law has become more lenient. In the United States, for example, bankruptcy law protects the debtor with rules that exempt specified portions of various asset types from the reach of the creditor. In addition, U.S. bankruptcy law gives debtors a ''fresh start'' by requiring the discharge of all debts remaining at the end of bankruptcy proceedings.

Bankruptcy exemptions and debt discharge have been a battleground in the area of U.S. bankruptcy law. The preeminent legal scholar in this area, Thomas Jackson

(1986, p. 233), states: ‘‘To many critics of the Code, discharge is granted without sufficient inquiry into the debtor’s ability to pay, and this provides an incentive to resort to bankruptcy unnecessarily and wastefully . . . [so that] discharge risk may make . . . credit unavailable or very expensive.’’ But Jackson proceeds to defend discharge on the grounds that ‘‘individuals appear to make choices by processing information in a way that consistently underestimates future risks.’’ In other words, inasmuch as individuals have a psychological tendency to underestimate future risks, it is appropriate to use bankruptcy law discharge provisions as a device for transferring risk away from individuals to institutions whose primary expertise lies in the area of risk assessment.

The present model formalizes this point of view. We have argued above that unlimited liability, which does little to deter optimistic entrepreneurs directly, may lower interest rates and indirectly encourage overly aggressive investment, just as collateral does. Compulsory bankruptcy exemptions and the discharge of remaining debts, by limiting the amount that creditors receive in the repayment of debt after default occurs, partially reverse this incentive: they increase the cost of credit[19] and help discipline optimists. This provides an efficiency justification for bankruptcy exemptions and discharge, which, like those currently in force in the United States, were motivated by a desire to protect less-well-off households.[20] It is important to note that these exemptions cannot be waived by debtors via private contracts.

In this article we have focused on entrepreneurial optimism. Our model assumes that bankers, unlike optimistic entrepreneurs, interpret all available information rationally. One may argue, however, that there is no reason to believe that bankers are intrinsically less overconfident than entrepreneurs. Indeed, there are instances in which banks have exhibited patterns of behavior that can most naturally be attributed to optimism. (The lending booms that preceded the recent banking crises in Latin America and Asia may have resulted in part from banker overconfidence.)

Optimistic bankers would tend to lend too much to firms with bad projects and underestimate the need for collateral protection. However, unlike the situation of small entrepreneurs, most bankers finance many projects, so that the law of large numbers can be expected to apply. Whereas an optimistic entrepreneur may enjoy good luck and get rich, this would seem rather improbable for an optimistic banker, at least insofar as his risks are uncorrelated. Furthermore, optimism on the part of an entrepreneur may provide incentives for a form of behavior, such as hard work, that increases the probability of a good outcome. The opposite may well be the case for an optimistic banker. Consequently, unrealistic optimism in bankers would seem to represent a direct threat to the soundness and financial stability of the banking system, thus increasing the need for adequate prudential regulation. In this respect, capital requirements imposed on banks can serve as devices to restrain optimistic bankers, much as bankruptcy exemptions lead banks to restrain the overly bold behavior of optimistic borrowers.

It is our contention that unrealistic entrepreneurial optimism, a well-established psychological trait, may have far-reaching implications for the functioning and efficiency properties of many different markets, although here we have concentrated our attention on the credit market alone. It is our belief that the implications of unrealistic optimism may be as important as those that derive from standard adverse selection and moral hazard problems, which in contrast to unrealistic optimism have been extensively researched. We hope to further pursue this research avenue involving overconfident,

[19] See Gropp, Scholz, and White (1997) for supporting empirical evidence.

[20] The current exemptions were first introduced by the U.S. Bankruptcy Reform Act of 1978, after having been recommended by the Commission on Bankruptcy Laws of the United States in 1973. Specific exemption amounts are controlled by state legislatures and are state specific.

but near-rational, entrepreneurs to cast new light on some still puzzling issues, such as the problem of security design and the determinants of the capital structure of nonfinancial firms.

Appendix A

■ *Proof of* $y = 0$. Because second-period interest factors and the perceived probability of receiving a good signal in the second period are independent of the first-period signal, the dynamic incentive to move from h to ℓ is also independent of the first-period signal. However, we know from (3) that the corresponding static incentive is greater for the entrepreneur with a b-signal than it is for the entrepreneur with a g-signal. Consequently, in any equilibrium with $x < 1$ (the entrepreneur with a g-signal sometimes chooses ℓ), the entrepreneur with the b-signal would strictly prefer ℓ, so that $y = 0$. For any equilibrium with $x = 1$, an entrepreneur with a b-signal who invests at level ℓ would be revealed as a realist and would thus gain dynamic benefits to reinforce his static preference for ℓ. Consequently, $x = 1$ also implies $y = 0$.

Appendix B

■ **The social planner's dynamic problem.** In this Appendix we analyze the social planner's investment choices in period 1. We proceed by backward induction. If the entrepreneur receives the b-signal in the first period, then he is revealed as a realist, and he will be assigned investment levels corresponding to his signals in each of the two periods. So suppose the entrepreneur receives the g-signal in period 1. Then in period 2, the planner will face one of the following information sets: $\{ghsg\}$, $\{ghng\}$, $\{g\ell g\}$, $\{ghsb\}$, and $\{g\ell b\}$, where, for example, $\{ghsg\}$ indicates a g-signal followed by an h investment and success, s, and then another g signal.

Now suppose that the planner has followed a separation strategy in period 1, assigning the h-investment to the g-signal. If the information set $\{ghsg\}$ is reached, the probability that the entrepreneur is a realist is μ. Consequently, the social planner's investment decision in this information set coincides with his decision in the static model, i.e., the switchpoint between pooling and separation in period 2 is given by

$$\Delta Y_G = \Delta\overline{C} = \frac{\overline{r}}{\rho} - \frac{1-\rho}{\rho} Y(B, h). \tag{B1}$$

If the information set $\{ghng\}$ is reached, the entrepreneur is revealed as an optimist. Therefore, the investment project of this entrepreneur in period 2 is good with probability γ and bad with probability $1 - \gamma$. Consequently, the planner's switchpoint $\Delta\hat{C}$ between pooling and separation in period 2 for $\{ghng\}$ is given by (B1), but with ρ replaced by γ.

If the information set $\{ghsb\}$ is reached, the social planner will specify the ℓ-investment.

Now suppose that the planner has followed the pooling strategy in the first period, assigning the ℓ-investment to the g-signal. If the information set $\{g\ell g\}$ is reached, the probability that an entrepreneur is a realist is $\mu\gamma/[\mu\gamma + (1 - \mu)] < \mu$, which in turn implies that the probability a project with signal g has quality G is $\varphi = \gamma/[\mu\gamma + (1 - \mu)] < \rho$. Consequently, for $\{g\ell g\}$, the switchpoint $\Delta\tilde{C}$ between pooling and separation in period 2 is given by (B1), with ρ replaced by φ.

Since $\gamma < \varphi < \rho$, it follows that

$$\Delta\overline{C} < \Delta\tilde{C} < \Delta\hat{C}. \tag{B2}$$

If the information set $\{g\ell b\}$ is reached, the social planner will specify the ℓ-investment.

Let W_{s2} be the expected social welfare in period 2 when the social planner separates the investment levels assigned to each of the two signals in period 1, and let W_{p2} be the analogous expression when the social planner pools the signals in period 1. The social planner would choose to separate the investments made for good and bad signals in period 1 for parameter values that make $(W_s + W_{s2}) - (W_p + W_{p2}) > 0$, and he would choose to pool for parameter values that make $(W_s + W_{s2}) - (W_p + W_{p2}) < 0$, where W_s and W_p are defined in equations (16) and (17) above.

From (B2), algebraic manipulations yield that $W_{s2} - W_{p2} = 0$ for $\Delta Y_G < \Delta\overline{C}$ and $\Delta Y_G > \Delta\hat{C}$, and $W_{s2} - W_{p2} > 0$ for $\Delta\overline{C} < \Delta Y_G < \Delta\hat{C}$. Hence, the socially optimal investment strategy is to assign the high level of investment to projects with the good signal and the low level of investment to projects with the bad signal, whenever $\Delta Y_G \geq \Delta\overline{C}$, exactly as in the static model.

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