Entrepreneurial Boldness and Excessive Investment

Isabelle Brocas
University of Southern California and CEPR
Los Angeles, CA 90089
brocas@usc.edu

Juan D. Carrillo
University of Southern California and CEPR
Los Angeles, CA 90089
juandc@usc.edu

We analyze investment by a population of hyperbolic discounting entrepreneurs. In order to avoid inefficient procrastination, agents with good prospects about their chances of success may choose to forego free information and to invest boldly. This explains an excessive level of investment in the economy. Building on this observation, we show that low risk-free interest rates favor bold entrepreneurship and entry mistakes. Furthermore, public intervention can be socially desirable: Forcing agents to acquire information before deciding whether to invest may reduce competitive interest rates and may be beneficial for all individuals in the economy.

And thus the native hue of resolution
Is sicklied o'er with the pale cast of thought,
And enterprises of great pith and moment
With this regard their currents turn awry,
And lose the name of action.

Hamlet, Act 3: Scene 1.

1. Introduction

In manufacturing industries, 61.5% of newly created companies are no longer in business after five years (data reported in Camerer and Lovallo,

We thank Mathias Dewatripont, Patrick Legros, Michael Manove, Jorge Padilla, Marco Pagano, Howard Rosenthal, Oved Yosha, seminar participants at ULB, CERGE-EI, MIT, Stockholm (IIES and SSE), IUE (Florence), London (LSE and CEPR-ESRC workshop), Lausanne, the CEPR Psychology and Economics workshop, Rutgers, two anonymous referees, and very specially Denis Gromb and Bruno Jullien for helpful comments and discussions.

Journal of Economics & Management Strategy, Volume 13, Number 2, Summer 2004, 321–350

1999). Similar patterns are observed in the works of Daly (1990) and Shapiro and Khemani (1987). The behavioral finance literature suggests that these levels of failure rates can be explained only by entrepreneurial bounded rationality in the form of overconfidence and/or optimism at the project initiation stage.[1] The objective of this paper is to turn Hamlet's lament on its head. Instead of assuming a cognitive bias in the process and evaluation of information, we argue that entrepreneurs with initially good prospects about the chances of success of their investment projects optimally may decide to keep this positive attitude and to invest boldly without looking for additional, free information. Although individually optimal, this behavior leads to an excessive level of investment in the economy, and to inefficiently high rates of business failure. More importantly, it may have negative aggregate consequences: Welfare Pareto improvements may be reached by forcing all potential investors to acquire as much evidence as possible before the investment decision.

The argument of the paper is as follows. There is a population of cash-constrained agents who consider the possibility of borrowing capital from banks in order to undertake a risky investment. Our main departure from standard modeling is the assumption that agents have dynamically inconsistent preferences [in the sense of Strotz (1956)], with short-term events being discounted at a relatively higher rate than long-term events. Although still challenged in behavioral and experimental economics (see Rubinstein, 2000 and Read, 2001, among others), this assumption is becoming more and more accepted in the light of the empirical and experimental evidence gathered [see Frederick, Loewenstein, and O'Donoghue (2002) for a survey]. Apart from hyperbolic discounting, the special characteristics relevant for our model are twofold. First, investment requires a current net cost (effort to find a potentially valuable project or foregone fixed outside salary) and yields a delayed expected net benefit (profit if the project is successful). Second, individuals do not know the probability of success of their project, although they can learn it (for simplicity at no cost).

Combining the taste for immediate gratification to this temporal gap between costs and benefits of entrepreneurial activities, we first show that individuals who are aware of their self-control problem optimally may keep good prospects about the value of their project and may make uninformed investments. The reason is that, under hyperbolic discounting, extra pieces of news have both benefits and costs. On the one hand, with more information the entrepreneur is less likely to

1. See Larwood and Whittaker (1977), Cooper, Woo, and Dunkelberg (1988), and DeBondt and Thaler (1995), among others for evidence of managerial overconfidence.

undertake worthless projects. However, on the other hand, information also can plunge the agent into a state of inefficient procrastination. Overall, a necessary condition for ignorance being beneficial is that it must induce an extra desire to invest. Hence, our economy can be composed only of "realist" agents (who invest according to their cost-benefit analysis at the time of exerting effort), of "bold" agents (who remain uninformed and, on average, invest in excess), or of both. This completes the first step toward "rationalizing" entry mistakes.[2]

This conclusion is reminiscent of Carrillo and Mariotti (2000). It relies on individual investments being self-financed or, equivalently, financed at an exogenously fixed interest rate. The novelty of the current paper is that agents need external financing. Hence, the net returns for an entrepreneur of a given project—and therefore her incentives to remain strategically ignorant and invest—depend on the interest rate set by banks in the economy. Interestingly, the interest rate itself will be determined depending on the learning decision of all the potential borrowers. Therefore, interest rate and level of entrepreneurship in the economy are determined jointly in equilibrium. Assuming perfect competition between banks and a fixed (exogenous) risk-free rate, the paper draws several conclusions. We show in Proposition 1 that there is an endogenous negative relation between the proportion of bold entrepreneurs in the economy and the risk-free rate. In fact, there are two reasons for which agents will undertake more investments in our economy when the risk-free rate is low. One is rather obvious: If the opportunity cost of investing becomes lower, the total number of entrepreneurs willing to invest increases. This effect highlights the usual relation between the state of the credit market and the number of profitable investments undertaken. The other, which is one of the main points of the paper, is more subtle: As the risk-free rate decreases, more agents are willing to remain strategically ignorant and to invest blindly. This effect relates the state of the credit market to the number of excessive investment projects undertaken. To understand the intuition, one must note two things. First, when the risk-free rate is relatively high, competitive banks are forced to charge high interest rates because the opportunity cost of lending also is relatively high. Second, when

2. Some readers argue that hyperbolic discounting is a form of bounded rationality. We do not see it that way. In particular, by adding one extra axiom, it is possible to incorporate time-varying preferences in the standard neoclassical paradigm (see Gul and Pesendorfer, 2001). However, we do not want to focus the debate on this issue. Therefore, from now on we will argue simply that our agents "optimize" their decisions in the sense that (i) they maximize profits conditional on their information; (ii) they update beliefs in a Bayesian way (i.e., unlike optimistic or overconfident individuals, they do not incur systematic biases in judgment and information processing); and (iii) they acquire the optimal amount of information anticipating future profit maximization.

the interest rate charged by banks is high, it is relatively more costly to undertake an investment, and therefore agents have more incentives to learn their chances of success before deciding whether to apply for a loan. The combination of both factors leads to the result. Note that this boldness and excessive entry may explain some aspects of the DotCom bubble, at a time where external financing was easy and cheap.[3]

At this stage, we can specify in which sense the level of investment in our economy is "excessively high," a concept loosely employed up to now. By definition, the learning and investment behavior is individually optimal, given the conditions of the market. However, Proposition 2 highlights a coordination failure: If individuals could be forced collectively to learn their probability of success before applying for the loan, then the level of investment in the economy would be smaller, and all agents would be strictly better off. The reason for this relies on the fact that acquiring information has a public good effect. Indeed, an agent who learns his probability of success will not apply for a loan if the expected value of the project is below a certain threshold. Therefore, learning triggers self-selection, which raises the average quality in the pool of applicants. This decreases the competitive interest rate set by banks (lower interest rates can be offered if applicants are, on average, better), which is beneficial for all the agents in the economy. When the (individual) benefits of remaining ignorant are offset by the (collective) gains due to a lower interest rate in the economy, then all agents are strictly better off with a policy measure that forces them to acquire information. This Pareto superior result is quite robust in that it applies both from the perspective of the individual who decides whether to learn and from the perspective of the individual who decides whether to invest. To sum up, this is the first study in which agents in an economy are linked to each other by their hyperbolic discounting and, as a result of their time-varying preferences, they behave in an individually optimal but collectively inefficient way. The results hold, although they are somewhat mitigated, when entrepreneurs also can post some collateral (Proposition 3). Lastly, when entrepreneurs have different levels of ability, those with highest skills also are most likely to keep positive prospects and invest.

It is interesting to compare our results with the recent developments in behavioral finance. Just like in our paper, in the literature on optimism and overconfidence, individuals have a tendency to overinvest. There are, however, two major differences. First, in our model and by definition of Bayesian information processing, first-order beliefs cannot

3. We thank an anonymous referee for suggesting this example.

be biased. So, our agents do not suffer from optimism or overconfidence. Yet the endogenous decision to stop the collection of information affects the higher order moments of beliefs in the population (and in particular the skewness of the distribution of beliefs) and therefore tilts the aggregate behavior toward an excessive level of investment. By contrast, in the recent literature, agents have (irrational) biased beliefs. In other words, our paper *provides a reason and a mean* to keep a positive view, whereas these papers *assume* a cognitive bias and use it to explain other important phenomena.[4] As developed in the concluding section, the second major difference is that changes in the ability to post collateral and in the risk-free rate will have different (testable) effects on the behavior of entrepreneurs depending on whether keeping positive prospects is instrumental as in our paper or exogenous as in the previously mentioned ones. There is a special mention to the work by Bernardo and Welch (2001). In that paper, overconfident entrepreneurs have an excessive tendency to avoid the herd, a behavior that is suboptimal individually but socially beneficial because it conveys valuable information to other entrepreneurs. Thus, in their paper, optimism exerts a positive rather than a negative externality on the population.[5] Lastly, the reader might wonder how important strategic ignorance is in corporate investments. Obviously, this is an empirical question. However, casual evidence on reports by bank loaners suggests that few market studies are conducted by people willing to start small businesses such as restaurants or night shops. Naturally, this may be due simply to lack of entrepreneurial skills. We believe instead that weighing the pros and cons of becoming an entrepreneur is the surest way for Hamlet as well as for most individuals never to take that step.

2. The Model

2.1 Preliminaries

We analyze the decision of agents to undertake an investment. Investing requires one unit of capital and one unit of effort. We denote by e the cost of exerting this effort. One can think of effort as the search cost in order to find a suitable project or the opportunity cost of becoming

4. To give a few examples of this literature, Roll (1986) proposes overconfidence as an explanation for the proliferation of corporate takeovers with no expected gains. Manove (1997) shows that optimistic entrepreneurs may drive realistic ones out of the market. Manove and Padilla (1999) argue that banks are insufficiently conservative in their dealings with optimistic entrepreneurs. Heaton (2002) proposes managerial optimism as an alternative foundation for pecking-order and agency-cost theories.

5. The key difference with our work is the nature of the private information: pure common value in their paper and pure private value in ours.

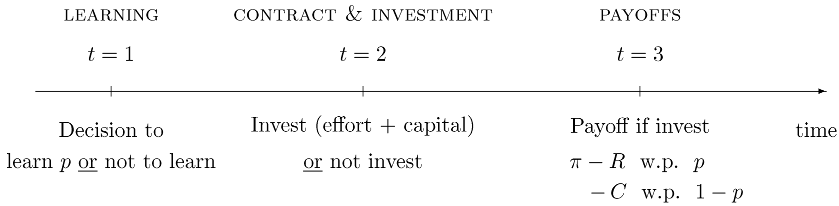

FIGURE 1. TIMING

an entrepreneur and invest rather than being an employee. Agents are cash constrained. They can borrow from banks the unit of capital only to invest. We denote by $R(\geq 1)$ the interest factor—i.e., one plus the interest rate—charged by banks. Furthermore, agents also can post some collateral C. For the time being, we assume that R and C are fixed, but these values will be determined endogenously in the optimal contract. The investment has a one-period delayed stochastic payoff. More specifically, with probability p the investment is successful and yields benefit π. With probability $1 - p$, the investment fails and yields zero benefit. Agents are ignorant of the probability p that their investment succeeds, but they know the probability distribution $F(p)$ with $p \in [0, 1]$, from which each p is drawn independently. We assume that the distribution satisfies the standard monotone hazard rate condition.

Assumption 1: $\frac{F(p)}{f(p)}$ is increasing in p.

The payoff of not investing is normalized to zero. Agents are risk neutral and have limited liability. Banks observe whether the investment succeeds or fails, so profits are contractible. Banks offer a debt contract to the potential applicants at the time where the investment project has to be initiated. The contract specifies a repayment $R(\leq \pi)$ in case of success and the appropriation of the collateral C (if any) in case of failure. Last, agents can learn *at no cost* the probability p that their own investment is successful the period before investing (i.e., before meeting the banks and applying for the loan).[6] This learning decision is not observable by banks. The timing can be summarized as in Figure 1.

Notice that the main assumption in this model is that there is a short-run opportunity cost of becoming an entrepreneur relative to being a salaried employee (extra effort, search costs, loss of current wage,

6. The assumption that agents cannot learn the probability of success at the date of exerting effort and investing is adopted only for simplicity: Carrillo and Mariotti (2000) show that the insights obtained in an infinite horizon model with hyperbolic discounting individuals who can learn at every date are the same as in a three-period model where learning is possible only in the first one.

etc.) that may pay in the long term (extra return on investment compared to the fixed wage). This sequence of payoffs seems quite natural.[7]

Our investigation departs from standard analyses in that agents have dynamically inconsistent preferences. More precisely, we assume that the period-to-period discount rate falls monotonically. Given our three-period model, there is no loss in generality if we use the quasi-hyperbolic discounting introduced by Phelps and Pollak (1968). Formally, from the perspective of date t, periods $t+1$ and $t+2$ are discounted at a rate $\beta\delta$ and $\beta\delta^2$, respectively [with $\delta \leq 1$ and $\beta \in (0, 1)$].[8] Individuals are "sophisticated," i.e., perfectly aware of the dynamic inconsistency of their preferences. The key effect of hyperbolic discounting is that the incentives to invest at $t = 2$ are different if we analyze them from the perspective of the agent at $t = 1$ (hereafter "self-1") than from her perspective at $t = 2$ (hereafter "self-2"). To focus on the interesting situation, we will assume that in the best possible scenario in which the investment succeeds for sure ($p = 1$) and in which the interest rate is zero ($R = 1$), self-2 finds it optimal to invest.

Assumption 2: $\beta\delta(\pi - 1) > e$.

We now can analyze the incentives of the different selves to invest.

2.2. Intrapersonal Conflict and Incentives to Invest

Suppose that the agent at date $t = 1$ learns his probability of success p. In that case, the investment has a positive expected utility from the perspective of self-1 if and only if

$$-\beta\delta e + \beta\delta^2[p(\pi - R) - (1 - p)C] \geq 0 \Leftrightarrow p \geq p_1 \equiv \frac{C + e/\delta}{\pi - R + C}. \quad (1)$$

However, when date 2 comes, self-2 chooses to invest if and only if

$$-e + \beta\delta[p(\pi - R) - (1 - p)C] \geq 0 \Leftrightarrow p \geq p_2 \equiv \frac{C + e/\beta\delta}{\pi - R + C}. \quad (2)$$

7. By contrast, the fact that there is exactly a one-period delay between the opportunity cost and the extra benefit of the investment is just a modeling device.

8. In recent years, this particular formalization of time-inconsistent preferences has been used to study different problems. Some examples are procrastination (Akerlof, 1991; O'Donoghue and Rabin, 1999); private-side bets (Caillaud, Cohen, and Jullien, 1996); consumption (Harris and Laibson, 2001; Krusell and Smith, 2003; Laibson, 1997); learning (Carrillo and Mariotti, 2000; Brocas and Carrillo, 2001, 2003); and memory management (Benabou and Tirole, 2002). See also Loewenstein and Prelec (1992), Ainslie (1992), and Caillaud and Jullien (2000) for a theoretical discussion of time-inconsistent preferences.

In a different vein, a time-inconsistent behavior may result from anticipatory feelings about future events even if agents discount the future with the traditional exponential functions (see Caplin and Leahy, 2000, 2001).

First, note that $p_1 < p_2$. Hyperbolic discounting induces procrastination: Some investments valuable for self-1 are not undertaken by self-2. The idea is simple. An agent finds it profitable to exert a cost in the future in order to obtain an expected benefit one period later if the chances of success are sufficiently important (formally, if $p \geq p_1$). However, given that present payoffs are overweighed, she may decide not to invest when the time at which the cost e has to be incurred arrives (Formally, this occurs when $p \in [p_1, p_2]$). This behavior is anticipated perfectly at date $t = 1$ by the sophisticated agent. However, in the absence of a commitment device, he can do nothing to counteract it. Second, both $p_1(R, C)$ and $p_2(R, C)$ are increasing in R and C: The higher the interest factor and collateral, the smaller the agent's expected gain of investing and therefore the smaller the incentives to invest from the perspective of any self. Lastly, when β increases, the intrapersonal conflict diminishes ($\partial p_2/\partial\beta < 0$), and, naturally, it vanishes when $\beta = 1$ ($\lim_{\beta\to 1} p_2(\beta) = p_1$).

Given agents' risk neutrality and using (1) and (2), it is immediate that, conditional on not learning the probability of success at date 1, investment is desirable from self-1's viewpoint if $E[p] \geq p_1$ and from self-2's viewpoint if $E[p] \geq p_2$.

2.3 Incentives to Learn the Value of an Investment

We now analyze the incentives of an agent to acquire information about her payoff distribution for any given pair of interest factor and collateral (R, C) set by banks. Self-1's expected payoff if he decides to become *informed* (i.e., to learn the value of p) is

$$G_i(R, C; \beta) = \int_{p_2}^{1} [-\beta\delta e + \beta\delta^2 p(\pi - R) - \beta\delta^2(1 - p)C]\, dF(p)$$
$$= \beta\delta \left[\delta(\pi - R + C) \int_{p_2}^{1} p\, dF(p) - (e + \delta C)[1 - F(p_2)] \right]. \quad (3)$$

Note that for all (R, C), $G_i(R, C; \beta) > 0$. The problem for self-1 is the tendency of self-2 to reject projects that are valuable from her perspective. This inefficiency implies zero payoff in cases where positive profits could be achieved. Yet it never can induce a negative expected payoff from his perspective. Also, $\partial G_i/\partial R < 0$ and $\partial G_i/\partial C < 0$: An increase in repayment or collateral decreases the expected benefit of the investment.

If self-1 chooses to remain *uninformed*, her expected payoff depends on the anticipated behavior of an uninformed self-2. From Section 2.2, we know that if $E[p] < p_2$ the uniformed self-2 will not invest, which implies zero-payoff for self-1. By contrast, if $E[p] \geq p_2$ an uninformed self-2 will invest. In that case, self-1's expected gain is

$$G_u(R, C; \beta) = \int_0^1 [-\beta\delta e + \beta\delta^2 p(\pi - R) - \beta\delta^2(1 - p)C]\, dF(p)$$
$$= \beta\delta\left[\delta(\pi - R + C)\int_0^1 p\, dF(p) - (e + \delta C)\right]. \qquad (4)$$

Again, $\partial G_u/\partial R < 0$ and $\partial G_u/\partial C < 0$ for all (R, C): As under learning, when self-1 remains uninformed an increase in repayment or collateral decreases the expected profit.

Given (3), (4), and $G_i(R, C; \beta) > 0$, then self-1 strictly prefers to ignore the true p rather than to learn it if, conditional on $E[p] \geq p_2$, we have

$$g(R, C; \beta) \equiv \frac{1}{\beta\delta}[G_u(R, C; \beta) - G_i(R, C; \beta)] > 0,$$

which can be rewritten as

$$\delta(\pi - R + C)\int_0^{p_2} p\, dF(p) > (e + \delta C)F(p_2) \Leftrightarrow E[p \mid p < p_2] > p_1.$$

This result builds on Carrillo and Mariotti (2000) and is summarized as follows.

Lemma 1: *At date* t = 1 *the agent decides not to acquire information about his probability of success if and only if the following two conditions hold*:

$$E[p] > p_2(R, C); \quad \text{and} \qquad \text{(C1)}$$

$$E[p \mid p < p_2(R, C)] > p_1(R, C). \qquad \text{(C2)}$$

The idea is simple. Given time-inconsistent preferences and the cost-benefit sequence of payoffs, when $p \in [p_1, p_2]$ self-1 wants to invest but self-2 does not. Therefore, the only potential benefit for self-1 of remaining uninformed is that it may induce self-2 to invest when the true value of p lies in $[p_1, p_2]$. Naturally, the cost is that self-2 may take suboptimal decisions because of her imperfect knowledge. In particular, he might decide to invest when the true p is in $[0, p_1]$. Overall, a *necessary* condition for ignorance to be optimal is that it must avoid inefficient procrastination. This is to say that if self-1 does not learn, then self-2 strictly must prefer to invest (C1). However, this condition is not sufficient. Given (C1), if the true p lies in $[p_2, 1]$ it is irrelevant whether the agent learns it or not. (C2) simply states that, conditional on p being smaller than p_2, then the event $p \in [p_1, p_2]$ has to be relatively more likely than the event $p \in [0, p_1]$. That is, ignorance must have—on average and from self-1's perspective—more benefits (investment when $p \in [p_1, p_2]$) than costs (investment when $p \in [0, p_1]$).

Conditions (C1) and (C2) in Lemma 1 have been derived for given values of R and C. However, in our model, the interest factor and collateral will be determined endogenously in equilibrium by banks. It is important therefore to understand how the incentives of agents to learn are affected by changes in R and C. We have the following key intermediary result.

Lemma 2: *There exists a value β^* such that for all $\beta \in (\beta^*, 1)$ if the agent remains uninformed for some* R′ *(respectively,* C′*), then the agent remains uninformed for all* R < R′ (*respectively*, C < C′). *Also, if the agent learns for some* R′ (*respectively*, C′), *then the agent learns for all* R > R′ (*respectively*, C > C′).

Proof. See the Appendix. □

This lemma states that self-1 is less likely to remain ignorant the higher the interest rate and collateral. This occurs for two reasons. First, an increase in R or in C decreases the willingness to invest by an uninformed self-2 ($\partial p_2/\partial R > 0$ and $\partial p_2/\partial C > 0$). So, formally, (C1) is less likely to be satisfied when R and C are high. Second and closely related, for any given probability of success, an increase in R or in C decreases the net profit of investing. Recall that an uninformed agent always invests with an (*ex-ante*) higher probability than an informed one. Therefore, an increase in repayment obligation or collateral has a more frequent negative impact on the expected payoff under ignorance than under learning.[9] Formally, (C2) also is less likely to be satisfied when R or C are high.

To sum up, self-1's net benefit of ignorance decreases as the investment becomes more costly. Naturally, for some parameter constellations self-1 strictly will prefer always to learn or always to remain ignorant, independently of R and C. These cases are not interesting for the purpose of the paper, which is to study the endogenous interactions between interest rate and agents' incentives to learn and invest. The next lemma provides sufficient conditions that ensure that self-1's learning decision is affected by R and C.

9. This is true only if the self-control problem is not excessively acute. Indeed, when the intrapersonal conflict is very important, self-2 cares about her current payoff and disregards almost completely future ones, whereas self-1 internalizes both of them. In order to avoid this extreme situation, we impose a lower bound in the inconsistency parameter.

Lemma 3: *There exist two values* $\underline{\beta}, \bar{\beta} \in (\beta^*, 1)$ *and a class of functions* $\mathrm{F}(\cdot)$ *such that if*

(i) $\frac{\mathrm{E[p]}}{2} < \frac{\mathrm{e}}{\delta(\pi - 1)} < \mathrm{E}\big[\mathrm{p} \mid \mathrm{p} < \mathrm{E[p]}\big]$; *and*

(ii) $\beta \in [\underline{\beta}, \bar{\beta}]$,

then learning depends exclusively on (R, C). *More precisely, for any C there exists a function* $\mathrm{R}^*(\mathrm{C})$ *such that* $\mathrm{g}(\mathrm{R}^*(\mathrm{C}), \mathrm{C}; \beta) = 0$ *and* $\mathrm{g}(\mathrm{R}, \mathrm{C}; \beta) \lesseqgtr 0$ *if* $\mathrm{R} \gtreqless \mathrm{R}^*(\mathrm{C})$.

Proof. See the Appendix. □

Although the analytical derivation of (i) and (ii) is elaborated somewhat, the idea behind these two conditions is in fact simple and intuitive. First, from (C2) we know that ignorance can be of potential interest for agents only if the true probability of success falls in the inconsistency region (p_1, p_2) relatively more often than below it. However, these cutoffs are determined endogenously. Part (i) states the formal conditions on $F(\cdot)$, δ, π, and e such that, given $\beta \in (\beta^*, 1)$, p is more likely to take "intermediate" rather than "low" values. Second, the incentives to learn are not monotonic in the taste for immediate gratification. When β is sufficiently small, self-1 anticipates that self-2 will not invest if he remains uninformed, so he strictly prefers to learn p. When β is sufficiently high, there is almost no conflict between self-1 and self-2, and learning p is once again optimal. The interesting situation arises when the inconsistency parameter takes intermediate values (formally, $\beta \in [\underline{\beta}, \bar{\beta}]$).[10] Part (ii) states that, in this case, the benefits from learning are mitigated and both (C1) and (C2) will or will not hold depending on the contract (R, C) offered by banks.

To sum up, when (i) and (ii) are both satisfied, learning is entirely driven by the pair (R, C) set by banks. Interestingly, in the next section we will show that R and C will be determined by banks precisely depending on the decision to acquire information by all agents in the economy. This means that the learning choice of each agent will be affected indirectly by the choice of all other agents via the contract offered by banks. In order to focus on this situation, we assume for the rest of the paper that the conditions of Lemma 3 are satisfied.

Assumption 3: $F(\cdot)$, β, δ, π, and e are such that conditions (i) and (ii) hold.

10. See equations (9) and (11) in the Appendix, Section A.2 for the specific functional forms of $\underline{\beta}$ and $\bar{\beta}$.

As a consequence, the utility of each agent can be written as

$$u(R, C; \beta) = \begin{cases} G_u(R, C; \beta) & \text{if} \quad R \leq R^*(C) \\ G_i(R, C; \beta) & \text{if} \quad R > R^*(C). \end{cases} \tag{5}$$

We now can investigate the behavior of banks in a competitive credit market.

2.4 The Competitive Credit Market

Banks determine interest factor and collateral knowing that the contract offered at $t = 2$ has been anticipated by agents when selecting at $t = 1$ their optimal learning strategy. We assume that there is a large number of risk-neutral banks. We denote by $\bar{R}(\geq 1)$ the risk-free interest factor (i.e., one plus the risk-free rate) and assume that it is given exogenously. Banks do not observe the learning choice of each borrower and cannot impose it. Therefore, all agents posting the same collateral can borrow at the same rate. Besides, the entrepreneur and the bank cannot contract at $t = 1$ on the investment to be undertaken at $t = 2$. Banks however observe whether the investment is a success or a failure, so the contract signed at $t = 2$ can be made contingent on the future realization of profits.

Agents can borrow only in order to invest in their project. Naturally, banks never will offer a contract (R, C) for which they anticipate expected losses. However, the payoff of banks depends on whether agents are informed or are ignorant about their own probability of success when they apply for the loan. Denote by $(R_j(C), C)$, the pairs of competitive interest factor and collateral requirement charged by a bank to an agent who applies for a loan when it is common knowledge that the latter has learned ($j = L$) and has not learned ($j = N$) his probability of success, respectively. Formally,

$$E[p] \times R_N(C) + (1 - E[p]) \times C = \bar{R}; \quad \text{and} \tag{6}$$

$$E[p \mid p > p_2(R_L(C), C)] \times R_L(C) + (1 - E[p \mid p > p_2(R_L(C), C)]) \times C = \bar{R}. \tag{7}$$

From (6) and (7), it is easy to see that $R_N(C) > R_L(C) > C$ for all $C \in [0, \bar{R})$ and that $R_L(\bar{R}) = R_N(\bar{R}) = \bar{R}$. In fact, for any collateral requirement smaller than the repayment obligation and given (C1), all uninformed agents decide to apply for the loan. By contrast, an agent who learns p may prefer not to borrow capital in order to invest if her chances of success are below the threshold $p_2(R_L(C), C)$. This *self-selection* process of informed agents increases the average quality in the pool of applications. As a result, it diminishes the risk of default and therefore allows banks to reduce the interest factor without making losses. Overall, under incomplete but symmetric information (uninformed agents) projects have, on average, a lower profitability than under asymmetric information (informed agents).

3. Equilibrium and Welfare

In Sections 2.2 and 2.3 we studied the agents' incentives to acquire information and to invest for a given interest factor and collateral. In Section 2.4 we analyzed the break-even contract that can be offered by banks depending on the agents' learning decision. We now can combine both the agents' and banks' behavior in order to determine the equilibrium interest factor, collateral, and level of investment in the economy. For expositional convenience we first study the equilibrium in the economy when agents have no collateral (Section 3.1) and analyze the welfare losses due to the agents' time inconsistency (Section 3.2). The analysis then is extended to include collateral (Section 4.1) and different managerial abilities (Section 4.2).

3.1 Learning and Investment with No Collateral

Consider the case where agents have no collateral ($C = 0$). By abuse of notation, we call $R^* \equiv R^*(0)$, $R_N \equiv R_N(0)$, $R_L \equiv R_L(0)$, and drop the argument C from p_1 and p_2. The banks' debt contract only can specify a repayment R in case of success, which means that they cannot discriminate between informed and uninformed agents when offering a contract. Given perfect competition between banks and *ex-ante* homogeneity of individuals, we can rewrite our problem as the maximization of the agents' utility (5) subject to the banks' break-even constraints (6) and (7). Formally, we have problem P:

$$\text{P}: \quad \max_R u(R;\beta) = \begin{cases} G_u(R;\beta) & \text{if} \quad R \leq R^* \\ G_i(R;\beta) & \text{if} \quad R > R^* \end{cases}$$

$$\begin{aligned} \text{s.t.} \quad & E[p] \times R \geq \bar{R} && \text{if} \quad R \leq R^* \\ & E[p \mid p > p_2(R)] \times R \geq \bar{R} && \text{if} \quad R > R^*, \end{aligned}$$

which leads to the following result.

Proposition 1: *When* $C = 0$, *there exist two values* $\bar{R}_1$ *and* $\bar{R}_2$ ($>\bar{R}_1$) *such that*:

(i) *If* $\bar{R} < \bar{R}_1$, *the interest factor is* R_N $(=\frac{\bar{R}}{E[p]})$ *and no agent learns* p;

(ii) *If* $\bar{R}_1 \leq \bar{R} \leq \bar{R}_2$, *the interest factor is* R^* *and a fraction* $\alpha(\bar{R})$ *of agents learn* p, *with* $\alpha(\bar{R}_1) = 0$, $\alpha(\bar{R}_2) = 1$, *and* $\partial\alpha/\partial\bar{R} > 0$; *and*

(iii) *If* $\bar{R}_2 \leq \bar{R}$, *the interest factor is* R_L *(with* $R_L = \frac{\bar{R}}{E[p \mid p > p_2(R_L)]}$*) and all agents learn* p.

Proof. See the Appendix. □

The idea behind the different cases is the following. If the risk-free rate is sufficiently small [$\bar{R} < \bar{R}_1$, see part (i)], banks do not need to set a large interest rate to satisfy the break-even constraint. Given Lemma 2, the cost of ignorance is relatively low compared to its gain. Then, all agents prefer to remain uninformed at $t = 1$ as a commitment against procrastination, and they invest at $t = 2$. Overall, this case is characterized by a population of *bold entrepreneurs*. Agents are bold in the sense that they do not acquire information and prefer to "blindly jump into the water." This conduct leads to high failure rates and entry mistakes that could have been avoided with more acquisition of information.[11] However, it is *optimal*: First, individuals take the decision that maximizes their profit conditional on their information, and second, the endogenous decision to acquire pieces of news is itself optimized given the agents' preferences.

When the risk-free rate is sufficiently high [$\bar{R} > \bar{R}_2$, see part (iii)], banks need to impose a high interest rate to avoid expected losses. In that case, the benefits of learning the probability of success are important relative to the costs of inefficient procrastination. All agents strictly prefer to know the environment they are facing and, at date 2, only a fraction $1 - F(p_2(R_L))$ of them invest.

Last, there is a whole set of values [$\bar{R} \in [\bar{R}_1, \bar{R}_2]$, see part (ii)] for which the interest rate is fixed and equal to R^*. If $\bar{R}$ is close to $\bar{R}_1$, a competitive interest factor R^* is sustainable only if almost all agents remain ignorant (weak self-selection). If $\bar{R}$ is close to $\bar{R}_2$, an interest factor R^* is sustainable only if almost every agent becomes informed (strong self-selection). By definition, when the repayment is R^*, agents are indifferent between learning and not. Then, in the interval $[\bar{R}_1, \bar{R}_2]$, a change in the risk-free rate leads to a change in the fraction of individuals who become informed without affecting the repayment. This case demonstrates that bold and realist entrepreneurs may coexist in this economy and, by construction, may achieve the same expected profits from their self-1 perspective.

11. Formally, a proportion of agents $F(p_1(R_N))$ and $F(p_2(R_N))$ invest with expected net losses from self-1's and self-2's viewpoint, respectively.

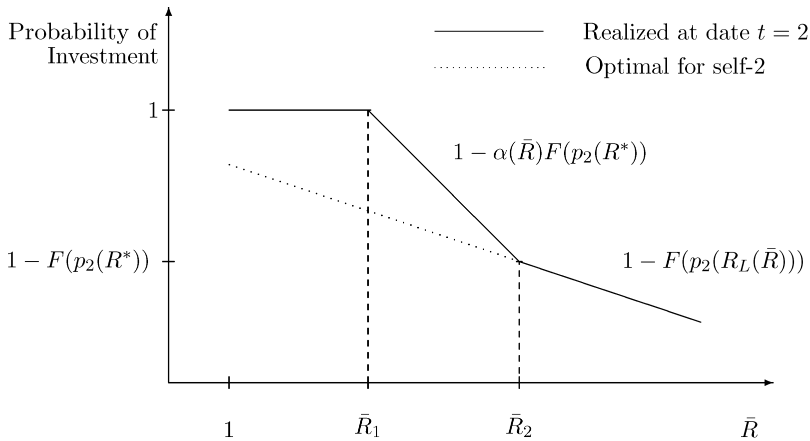

FIGURE 2. LEVEL OF INVESTMENT IN THE ECONOMY

The most important conclusion that can be obtained from Proposition 1 is that, as $\bar{R}$ decreases, more agents in the economy decide to invest. This occurs for two reasons. First and trivially, because the opportunity cost of investing is lower: R_N and R_L [and therefore $p_2(R_N)$ and $p_2(R_L)$] decrease with $\bar{R}$ [see equations (6) and (7)]. This is a straightforward negative relation between risk-free rate and number of *profitable* investments. But second and more importantly, because agents have more incentives to remain ignorant, the invest boldly and therefore incur in entry mistakes. Overall, there is also a negative relation between risk-free rate and degree of *excessive* investment in the economy.

Figure 2 depicts the level of investment in the economy as a function of the risk-free interest factor. The negative slope of the dashed line reflects the first effect. The difference between the full line and the dashed line reflects the second effect.[12]

It is interesting to compare the logic of our results with the classical reference by Keynes (1936) to the psychological factors affecting expectations: "A large proportion of our positive activities depend on spontaneous optimism rather than on a mathematical expectation, whether moral or hedonistic or economic. [. . .] Thus if the animal spirits are dimmed and the spontaneous optimism falters, leaving us to depend on nothing but a mathematical expectation, enterprise will fade and die" (pp. 161–62). According to his theory, "spontaneous optimism" (without any specification about where it comes from) breeds the

12. Note that the number of entry mistakes is decreasing in $\bar{R}$ also from self-1's viewpoint.

entrepreneurial appetite, which positively affects the economy. Our paper links expectations to entrepreneurship in a very different way. First, we claim that bold entrepreneurship is the result of an optimization process. Second, we show that good credit-market conditions (low interest rates) endogenously foster the willingness to keep positive views and not the other way around.

Before performing a welfare analysis, some points deserve further clarification. First, replacing hyperbolic discounting by costly learning does not generate the same predictions. An exponential discounting individual does not acquire costly information if the opportunity cost of investing is either sufficiently low ($\bar{R}$ small) or sufficiently high ($\bar{R}$ big). The first case is characterized by excessive boldness (uninformed investment) and the second one by excessive conservatism (uninformed noninvestment). In other words, the agent's incentives to acquire pieces of news are not increasing in R as in Lemma 2 but rather have an inverted U-shape. Naturally, the combination of hyperbolic discounting and costly information provides mixed results.

Second, an individual can keep the benefits of strategic ignorance and can reduce the costs (although never can eliminate them completely) by delegating the acquisition of news to a third party, who only reports a suitably chosen partition of the news collected. Although theoretically feasible, we find this possibility far-fetched, mainly because it is difficult for a party (1) to evaluate accurately information about someone else's project; and (2) to know how to optimally report news so as to avoid procrastination (not to mention the renegotiation-proofness problem it poses). In our view, this explains why we rarely observe delegation in practice.

Third, self-1 will be able to bias the behavior in a systematic way only if the optimal level of investment is a nonlinear function of the probability of success. This rules out the case in which all agents invest an amount proportional to p.[13]

Last and most importantly, we can relate our results to the standard credit-market literature. Following the seminal paper by Stiglitz and Weiss (1981), most of the literature compares asymmetric information (informed borrowers and uninformed lenders) to complete information (informed borrowers and informed lenders). A major result is that, as the interest rate increases, the adverse selection problem is exacerbated, implying that the average quality in the pool of applicants decreases (High-risk borrowers become relatively more attracted than low-risk

13. On the other hand, the binary choice is not necessary for the results: The same qualitative conclusion would hold if investment were a continuous variable and if zero investment were optimal below a certain threshold.

borrowers).[14] By contrast, our work compares imperfect but symmetric information (uninformed borrowers and uninformed lenders) to asymmetric information (informed borrowers and uninformed lenders). Interestingly, the conclusions are reversed. As the interest rate increases, the average quality in the pool of applicants increases: Ignorance becomes more costly, and entrepreneurs are then more likely to learn the quality of their project, so there is self-selection and application for a loan only if prospects are sufficiently good. This same intuition holds in a model of time-consistent individuals and costly learning if, under ignorance, a majority of them applies for a loan. However, to the best of our knowledge, such comparison has never been studied formally.

3.2 Social Welfare

We can be more precise now about what we mean by "excessive investment." At the individual level and from self-1's perspective, remaining ignorant implies investing too often, although it also may be the best way to avoid inefficient procrastination.

More importantly, we are concerned about excessive investment *from a societal perspective* and taking into account the welfare of both self-1 and self-2. To be more precise, suppose that the government could force all agents in the economy to learn their probability of success before applying for a loan. Obviously, this would be beneficial for each and every self-2, since they derive no benefit from inherited ignorance. Also, it would imply some self-selection and therefore would reduce the level of investment in the economy. The key question is whether such intervention would be profitable also from the agents' self-1 perspective. If the answer is "yes," then we can claim that a measure that reduces loan applications is Pareto improving, which in turn suggests that in the absence of such intervention the level of investment in the economy is excessively high from a social viewpoint. The next proposition answers that question.

Proposition 2: *There exists a value $\bar{R}'_1 < \bar{R}_1$ such that for all $\bar{R} \in [\bar{R}'_1, \bar{R}_2]$, the level of investment is strictly smaller and the welfare of all agents is strictly higher (both from their self-1 and their self-2 perspective) when all agents are forced to become informed than when they freely choose their learning strategy.*[15]

14. This, in turn, is the main argument for the optimality of credit rationing from the banks' viewpoint.

15. If $\bar{R} \geq \bar{R}_2$, then all agents strictly prefer to become informed, so public intervention is unnecessary.

Proof. See the Appendix. □

The idea is simple. An agent who learns her probability of success only applies for a loan if the quality of the project is above a certain threshold. This self-selection creates a positive externality on the economy because it induces a reduction in the competitive interest rate offered by banks. Naturally, agents do not internalize the public good effect of their learning decision: As we have pointed out already, in the absence of government intervention some or all of them individually may find optimal to refuse information and to invest blindly. Under these circumstances, Proposition 2 shows that forcing the acquisition of information can be desirable. This measure, directed to internalize the positive externality of information acquisition, decreases the number and increases the quality of projects. It is important to realize the strength of the result: By decreasing the total number of projects that are financed, public intervention increases expected welfare in a Pareto sense, i.e., for all individuals and from both their self-1 and self-2 perspective. It therefore is safe to say that, without intervention, the level of investment in the economy is excessively high from every point of view.

Admittedly, it may be difficult to find measures that encourage agents to acquire information. Requiring a market study with every loan application can induce potential investors to become conscious of their chances of success. A more indirect measure can be simply to enforce stricter bankruptcy rules: Increasing the cost of undertaking bad projects implicitly diminishes the net value of remaining ignorant.[16] Lastly, note that if banks could observe whether an applicant has learned or not, then government intervention would be unnecessary: Lower interest rates would be offered to informed borrowers and, as long as $\bar{R} \geq \bar{R}_1'$, everyone would have incentives to learn. However, this would only benefit the entrepreneurs because, in equilibrium, lenders would still compete "à la Bertrand" and would make no profit.

Note that many papers already have studied individual decisions by time-inconsistent agents. Just to give a few examples, Harris and Laibson (2001) and Krusell and Smith (2003) have determined the consumption behavior of a representative agent in different models of time-inconsistency; Carrillo and Mariotti (2000) have shown the gains of strategic ignorance; O'Donoghue and Rabin (1999) have studied interpersonal contracting between a hyperbolic discounting agent and an exponential discounting principal; and Brocas and Carrillo (2001) have analyzed the costs of cooperation and the gains of competition among several hyperbolic discounting agents. The novelty of our work

16. As we will see in Section 4.1, this measure is qualitatively similar to an increase in collateral.

relative to this literature is that the strategic behavior of each individual with a self-control problem (the decision to learn) influences the state of the economy (interest rate), which affects the welfare and behavior of the other agents. In other words, agents are linked endogenously to each other and to the whole economy by their time inconsistency and through the market interest rate (Proposition 1). Furthermore, this endogenous interaction may result in Pareto-inferior outcomes (Proposition 2).

More recent papers have developed related models with endogenous interactions between agents with self-control problems. In Jovanovic and Stolyarov (2002), each agent prefers an inefficient technology as a commitment against future excessive work. However, market forces destroy the commitment value of rejecting a modern technology and therefore reduce the welfare of all its members. In Battaglini, Benabou, and Tirole (2001), observing the behavior of others provides some information to each agent about the difficulty to resist temptations. Multiple equilibria characterized by self-restraint or self-indulgence coexist only as a result of social interactions.

4. Extensions

4.1 Learning and Investment with Collateral

A key reason for agents' willingness to keep positive prospects is the relatively small opportunity cost of investing: When the project fails, the entrepreneur only loses her cost of effort e. Allowing the use of collateral is likely to alter the cost of ignorance and therefore the overall equilibrium in the economy. Suppose that all agents can post a collateral C ($\leq R$).[17] Besides, assume for simplicity that each bank only can fix one pair of repayment and collateral (R, C) (This assumption is not crucial as discussed in Remark 1). The problem becomes the analogue of P to the case in which $C \in (0, R)$. We have:

Proposition 3: *When* $\mathrm{C} \leq \mathrm{R}$, *there exists a value* $\bar{\mathrm{R}}_0(<\bar{\mathrm{R}}_1)$ *such that:*

(i) If $\bar{\mathrm{R}} \leq \bar{\mathrm{R}}_0$, *then no agent learns p. The interest factor and collateral is any combination* $(\mathrm{R_N}(\mathrm{C}), \mathrm{C})$ *with* $\mathrm{C} \in [0, \bar{\mathrm{R}}]$; *and*

(ii) If $\bar{\mathrm{R}} > \bar{\mathrm{R}}_0$, *then all agents learn p. For each* $\bar{\mathrm{R}}$, *there exists an optimal combination of interest factor and collateral* $(\mathrm{R_L}(\hat{\mathrm{C}}(\bar{\mathrm{R}})), \hat{\mathrm{C}}(\bar{\mathrm{R}}))$ *with* $\hat{\mathrm{C}}(\bar{\mathrm{R}}) < \bar{\mathrm{R}}$.

Proof. See the Appendix. □

17. A collateral C greater than the repayment obligation R is not enforceable by the US contract law.

Posting collateral does not affect qualitatively our results; for low values of $\bar{R}$, agents still prefer to remain uninformed and to invest boldly. However, there are two new effects due to the use of collateral. First, ignorance is less likely to occur in equilibrium [Learning becomes optimal when $\bar{R} \in (\bar{R}_0, \bar{R}_2)$]. The reason is that the inclusion of collateral increases the cost of default on payment and therefore the net benefits of learning p and avoiding projects with low chances of success (see Lemma 2). Overall, agents who risk their collateral are less willing to invest boldly . However, for a risk-free rate sufficiently low, blind ignorance still remains optimal. Thus, in our theory, increasing repayment or collateral has essentially the same effect. This prediction sharply contrasts with overconfidence theories. As a (non-Bayesian) individual becomes more overly optimistic about his chances of success, a high repayment is perceived as more costly, but a high collateral requirement is perceived as less costly.

A second difference is that, with collateral, informed and uninformed agents do not coexist. Collateral adds a new dimension in which banks can compete for capturing entrepreneurs. Therefore, given an interest factor for which agents previously were playing a mixed strategy, there is now an optimal combination (R, C) such that one of the two alternatives (learning or ignorance) strictly dominates the other. However, this conclusion should not be taken too literally because it relies crucially on the two-dimension competition between banks (interest and collateral) and the two types of agents (fully uninformed and perfectly informed).[18]

Remark 1: Banks could reduce the rents of agents by offering a menu of contracts $(R(p), C(p))$ such that individuals would pick their preferred pair of reimbursement and collateral depending on whether they knew their probability of success. A full characterization of the optimal contract with a "maybe-informed agent" certainly is interesting but technically is complex and only tangential to the main point of the paper so we prefer to leave it aside [For an analysis along these lines, see Crémer, Khalil, and Rochet (1998)]. Nevertheless, it is safe to say that, even if we allowed this type of contract, the incentives for strategic ignorance still would operate.[19]

18. For instance, any model with gradual uncertainty resolution (where some individuals can be informed partially) will be characterized by a coexistence of agents in the economy with different degrees of information.

19. By contrast, if banks could observe whether the entrepreneurs know their probability of success, they would offer different types of contracts to each one. In that case, the decision of each individual to learn and to invest would be independent of the decision of others. Learning then would lose its public good value; agents would not be endogenously linked to each other by their self-control problem; and the results of Proposition 2 would not hold anymore.

4.2 Entrepreneurial Ability and Incentives to Invest

Are the conclusions reached so far modified if we incorporate differences in the ability of agents to undertake (or to evaluate) risky projects? Obviously, more able individuals are likely to succeed better in their investment projects. The interesting question is to determine whether these agents are more likely to act boldly or conservatively.

We define a high-ability entrepreneur as an individual who has a higher probability of success or who, conditional on succeeding, enjoys a higher payoff than other entrepreneurs. One can see immediately that the effect of increasing the benefit of success is exactly the opposite of that of increasing the repayment obligation: It raises (rather than reduces) the payoff in the good state of nature. Therefore, using the same argument as in Lemma 2 but in the opposite direction, we conclude that high-ability agents have more incentives to forego information and to invest boldly than their low-ability peers (The formal proof is omitted for the sake of brevity but it is available upon request). Overall, if we interpret e as the fixed short-term opportunity cost of entrepreneurship relative to a salaried occupation, agents with high capacity are more prone to self-select themselves into becoming investors rather than employees for two reasons: (1) and trivially, because the expected payoff of their projects is higher; and (2) because they are more willing to avoid information that would discourage some investments profitable from their self-1 viewpoint. Hence, there is a positive relation among intrinsic managerial capacity, decision to become an entrepreneur, and proportion of bold investors in the economy. At the same time, more capable managers also are more likely to commit entry mistakes.

5. Concluding Remarks

Instead of assuming non-Bayesian processing of information as the reason for overconfidence, this paper has shown that the willingness of entrepreneurs to keep positive thoughts can be an optimal choice in order to avoid inefficient procrastination. We also have offered some prescriptions for public intervention that may avoid excessively high levels of investment and may be beneficial for all agents in the economy. Our work does not pretend to question the existence of intrinsic optimists in the population—an observation for which there is large evidence. However, we feel that *deriving from preferences* an attitude observationally similar (although certainly not equivalent) to intrinsic, non-Bayesian optimism or overconfidence is an important step toward a better understanding of the motivations behind human conducts.

We would like to conclude by pointing out two directions for future research. First, it would be interesting to test whether entry mistakes are mainly the result of intrinsic optimism or instrumental willingness to keep positive views. There are at least two ways to discriminate between these two theories. In our work, the proportion of entry mistakes over total investments decreases if agents can post collateral and increases if the risk-free rate diminishes. By contrast, theories based on overconfidence suggest the opposite. By definition, optimistic individuals have an excessively low concern about the payoff in case of failure, so the capacity to post collateral exacerbates their inefficient behavior. Similarly, if interest rates are high only optimists apply for loans, whereas if interest rates are low these individuals are diluted in the whole population. Second, the paper highlights the negative relation between risk-free rate and boldness. From a dynamic perspective, one may conjecture that if current boldness leads to current entry mistakes, this may have a negative impact on the future state of the credit market. Should this be true, the economy could exhibit cycles: Periods of low interest rates and high levels of entrepreneurial activity would be followed by periods of high interest rates and moderate entrepreneurship.

Appendix

Proof of Lemma 2. It is obvious that $E[p] - p_2(R, C)$ is decreasing in both R and C. Noting that $p_2 = (\pi - R + C)\frac{\partial p_2(\cdot)}{\partial R}$ and $1 - p_2 = (\pi - R + C)\frac{\partial p_2(\cdot)}{\partial C}$, we obtain that

$$\frac{\partial g(R, C; \beta)}{\partial R} = \delta(p_2 - p_1)p_2 f(p_2) - \delta \int_0^{p_2} p f(p)\, dp$$

$$\frac{\partial g(R, C; \beta)}{\partial C} = \delta(p_2 - p_1)(1 - p_2) f(p_2) - \delta \int_0^{p_2} (1 - p) f(p)\, dp.$$

Suppose that for some C and $\beta \in (\beta^*, 1)$ there exists $\tilde{R}(C, \beta)$ such that $g(\tilde{R}(C, \beta), C; \beta) = 0$, and for some R and $\beta \in (\beta^*, 1)$ there exists $\tilde{C}(R, \beta)$ such that $g(R, \tilde{C}(R, \beta); \beta) = 0$. We have

$$\left.\frac{\partial g(R, C; \beta)}{\partial R}\right|_{\tilde{R}} \propto (p_2 - p_1)p_2 \frac{f(p_2)}{F(p_2)} - p_1$$

$$\left.\frac{\partial g(R, C; \beta)}{\partial C}\right|_{\tilde{C}} \propto (p_2 - p_1)(1 - p_2) \frac{f(p_2)}{F(p_2)} - (1 - p_1),$$

where $\propto$ stands for "proportional to." Given Assumption 1, $p\frac{f(p)}{F(p)} < 1$ for all p. Hence,

$$(p_2 - p_1)(1 - p_2)\frac{f(p_2)}{F(p_2)} - (1 - p_1) < (1 - p_1)\left[p_2\frac{f(p_2)}{F(p_2)} - 1\right] < 0 \Rightarrow \left.\frac{\partial g(R, C; \beta)}{\partial C}\right|_{\tilde{C}} < 0.$$

Note also that $p_1(R, C) \geq \beta p_2(R, C)$ for all $C \geq 0$. Therefore, for all $\beta > \beta^* = 1/2$,

$$(p_2 - p_1)p_2\frac{f(p_2)}{F(p_2)} - p_1 < p_1\left[\left(\frac{1}{\beta} - 1\right)p_2\frac{f(p_2)}{F(p_2)} - 1\right] < 0 \Rightarrow \left.\frac{\partial g(R, C; \beta)}{\partial R}\right|_{\tilde{R}} < 0.$$

To sum up, if we fix C and $\beta \in (\beta^*, 1)$, then $g(R, C; \beta)$ crosses the R-axis at most once. As a result, either $g(R, C; \beta)$ is always positive, or $g(R, C; \beta)$ is always negative, or there exists $\tilde{R}$ such that $g(R, C; \beta) \gtrless 0$ for all $R \lessgtr \tilde{R}$. The same conclusion applies with respect to C. □

Proof of Lemma 3.

- *Step 1:* Conditions for the problem to be well behaved. For all β, the probabilities are well defined, i.e., $p_1(R, C) \in (0, 1)$ and $p_2(R, C) \in (0, 1)$, if and only if

$$R \leq \pi - \frac{e}{\beta\delta} = R(\beta). \tag{8}$$

  According to Assumption 2, $\beta > \tilde{\beta} \equiv e/\delta(\pi - 1)$. Also, $R(\beta) > 1$ for all $\beta > \tilde{\beta}$. Therefore, under Assumption 2 and provided that π, δ, and e are such that $\frac{e}{\delta(\pi-1)} < 1$, the problem is well behaved for all $R \in [1, R(\beta)]$.
- *Step 2:* Conditions under which (C1) is satisfied. For all C, $E[p] > p_2(R, C)$ if and only if

$$R < \pi - \frac{e}{\beta\delta E[p]} - C\frac{1 - E[p]}{E[p]} = R(C, \beta).$$

  Note that $R(C, \beta)$ is decreasing in C and that $R(0, \beta) = \pi - \frac{e}{\beta\delta E(p)} < \pi - \frac{e}{\beta\delta} = R(\beta)$. As a consequence, there exists $\hat{\beta} > \tilde{\beta}$ such that $R(0, \hat{\beta}) = 1$. Besides, $R(C, \beta) < R(0, \beta) < 1$ for all $\beta < \hat{\beta}$. In other words, a necessary condition for (C1) to be satisfied is $\beta \geq \hat{\beta} = \frac{e}{\delta E[p](\pi - 1)}$ provided that π, δ, and e are such that $\frac{e}{\delta(\pi - 1)} < E[p]$. Let

β_1 and C_1 such that $R(C_1, \beta_1) = C_1 = 1$. By construction β_1 and C_1 are unique and $\beta_1 > \hat{\beta}$.

(1) for all $\beta \in [\hat{\beta}, \beta_1]$, there exists a unique $C_2(\beta) < C_1$ such that $R(C_2(\beta), \beta) = 1$ in which case (C1) is satisfied for all $C < C_2(\beta)$ and $R \in [1, R(C, \beta)]$; and
(2) for all $\beta > \beta_1$, there exists a unique $C_3(\beta) > C_1$ such that $R(C_3(\beta), \beta) = C_3(\beta)$ in which case (C1) is satisfied for all $C < C_3(\beta)$ and $R \in [C, R(C, \beta)]$.

- *Step 3:* Conditions under which $g(R, C; \beta) = 0$.

$$\frac{\partial g(R, C; \beta)}{\partial \beta} = \delta(\pi - R + C) f(p_2) \frac{\partial p_2}{\partial \beta}(p_2 - p_1) < 0 \quad \forall \beta < 1.$$

Besides, $g(R, C; 1) < \delta(\pi - R + C)F(p_2)(p_2 - p_1) = 0$ since $p_2 = p_1$ when $\beta = 1$. When $\beta = \hat{\beta}$, the only pair (R, C) satisfying (C1) is $R = 1$ and $C = 0$ and in that case $p_2 = E[p]$. Moreover,

$$g(1, 0; \hat{\beta}) = \delta(\pi - 1) \int_0^{E[p]} p\, dF(p) - eF(E[p]),$$

and $\operatorname{sign} g(1, 0; \hat{\beta}) = \operatorname{sign}[E[p \mid p < E[p]] - \frac{e}{\delta(\pi - 1)}]$. Then, we have two cases:

(1) $F(\cdot)$ is such that $E[p \mid p < E[p]] > \frac{E[p]}{2}$

(i) if $\frac{e}{\delta(\pi - 1)} \in [E[p \mid p < E[p]], E[p]]$, then $\hat{\beta} > 1/2$ and $g(1, 0; \hat{\beta}) < 0$. Since $g(\cdot)$ is decreasing in R and C for all $\beta > 1/2$, $g(R, C; \beta) < 0$ for all R and C and the agent always learns;

(ii) if $\frac{e}{\delta(\pi - 1)} \in [\frac{E[p]}{2}, E[p \mid p < E[p]]]$, then $\hat{\beta} > 1/2$ and $g(1, 0; \hat{\beta}) > 0$. Therefore there exists $\beta > \hat{\beta}, C$ and $R^*(C)$ such that $g(R^*(C), C; \beta) = 0$. More precisely, for all $\beta > \hat{\beta}$, there exists $(\tilde{R}(\beta), \tilde{C}(\beta))$ such that $(\tilde{R}(\beta), \tilde{C}(\beta)) = \operatorname{argmin} g(R, C; \beta)$. Let β' be such that $g(\tilde{R}(\beta'), \tilde{C}(\beta')) = 0$. By construction, $\beta' > \hat{\beta}$ and for all $\beta < \beta'$, $g(R, C; \beta) > 0$, in which case the agent never learns. In addition, there also exists $\bar{\beta}$ such that $g(1, 0; \bar{\beta}) = 0$, i.e., that solves

$$\delta(\pi - 1) \int_0^{\frac{e}{\delta\bar{\beta}(\pi-1)}} p\, dF(p) - eF\left(\frac{e}{\delta\bar{\beta}(\pi - 1)}\right) = 0. \tag{9}$$

and for all $\beta > \bar{\beta}$, $g(R, C; \beta) < 0$ and the agent always learns. Naturally, $\bar{\beta} \geq \beta'$ by construction; and

(iii) if $\frac{e}{\delta(\pi-1)} \in (0, \frac{E[p]}{2}]$, $\hat{\beta} < 1/2$ and $g(1, 0; \hat{\beta}) > 0$. Moreover,

$$g\left(1, 0; \frac{1}{2}\right) = -eF\left(\frac{2e}{\delta(\pi-1)}\right) + \delta(\pi-1)\int_0^{2e/\delta(\pi-1)} pf(p)\,dp,$$

and sign $g(1, 0; \frac{1}{2}) = \text{sign} E[p \mid p < \frac{2e}{\delta(\pi-1)}] - \frac{e}{\delta(\pi-1)}$. It is easy to verify that $g(1, 0; \frac{1}{2}) > 0$ when $\frac{e}{\delta(\pi-1)} = \frac{E[p]}{2}$. Therefore, there exist π, e and δ satisfying $\frac{e}{\delta(\pi-1)} \in (0, \frac{E[p]}{2}]$ such that $g(1, 0; \frac{1}{2}) > 0$. In that situation, using the same reasoning as before, we can characterize $\bar{\beta} > \beta' > 1/2$ such that (i) for all $\beta < \beta'$, the agent never learns; (ii) for all $\beta > \bar{\beta}$, the agent always learns; and (iii) for all $\beta \in [\beta', \bar{\beta}]$, there exist $R^*(C)$ such that $g(R^*(C), C; \beta) = 0$. Naturally, if e, π, and δ are such that $g(1, 0; \frac{1}{2}) < 0$, the agent learns for all $\beta > 1/2$ and for all R and C suitably chosen.

(2) $F(\cdot)$ is such that $E[p \mid p < E[p]] < \frac{E[p]}{2}$

(i) if $\frac{e}{\delta(\pi-1)} \in [\frac{E[p]}{2}, E[p]]$, then $\hat{\beta} > 1/2$ and $g(1, 0; \hat{\beta}) < 0$. Since $g(R, C; \beta)$ is decreasing in both R and C for all $\beta > 1/2$, $g(R, C; \beta) < 0$ for all R and C;

(ii) if $\frac{e}{\delta(\pi-1)} \in [E[p \mid p < E[p]], \frac{E[p]}{2}]$, then $\hat{\beta} < 1/2$, $g(1, 0; \hat{\beta}) < 0$ and $g(1, 0; 1/2) < 0$. Therefore, $g(R, C; \beta) < 0$ for all R, for all C and for all $\beta > 1/2$; and

(iii) if $\frac{e}{\delta(\pi-1)} \in (0; E[p \mid p < E[p]]]$, $\hat{\beta} < 1/2$ and $g(1, 0; \hat{\beta}) > 0$. Here again, if π, e, and δ satisfy $\frac{e}{\delta(\pi-1)} \in (0, E[p \mid p < E[p]]]$ and are such that $g(1, 0; \frac{1}{2}) > 0$, we can determine (as before) $\bar{\beta} > \beta' > 1/2$ such that (i) for all $\beta < \beta'$, the agent never learns; (ii) for all $\beta > \bar{\beta}$, the agent always learns; and (iii) for all $\beta \in [\beta', \bar{\beta}]$, there exist $R^*(C)$ such that $g(R^*(C), C; \beta) = 0$. By contrast, if e, π, and δ are such that $g(1, 0; \frac{1}{2}) < 0$, the agent learns for all $\beta > 1/2$ and for all R and C suitably chosen.

- *Step 4:* Conditions for $R^*(C)$ to be the frontier between learning and not.

$$\frac{\partial R^*}{\partial C} = -\frac{\partial g(R^*(C), C)}{\partial C} \Bigg/ \frac{\partial g(R^*(C), C)}{\partial R} < 0, \tag{10}$$

and

$$\frac{\partial R^*}{\partial C} = -\frac{f(p_2)(1-p_2)(p_2-p_1) - \int_0^{p_2}(1-p)\,dF(p)}{f(p_2)p_2(p_2-p_1) - \int_0^{p_2}(p)\,dF(p)} < -\frac{1-E(p)}{E(p)}$$

$$= \frac{\partial R(C, \beta)}{\partial C}.$$

As a consequence, a sufficient condition for $R^*(C)$ to be the frontier between learning and no learning is $g(R(0, \beta), 0, \beta) < 0$, which ensures that $R^*(0) < R(0, \beta)$. Otherwise, the frontier $K(C)$ is kinked, and there exists $\hat{C}$ such that $R^*(\hat{C}) = R(\hat{C}, \beta)$. In that case, we have:

$$K(C) = \begin{cases} R(C, \beta) & \text{if} \quad C \leq \hat{C} \\ R^*(C) & \text{if} \quad C > \hat{C} \end{cases}$$

Since $R(0, \beta) = \pi - e\beta\delta E(p)$, in which case $p_2 = E(p)$, there exists $\underline{\beta} \in (\beta', \bar{\beta})$ such that $K(C) = R^*(C)$ for all $\beta \in (\underline{\beta}, \bar{\beta})$. Besides,

$$\underline{\beta} = \frac{E[p \mid p < E(p)]}{E(p)}. \tag{11}$$

Naturally, the frontier is kinked when $\beta \in (\beta', \underline{\beta})$. □

Proof of Proposition 1. Note first that if $\bar{R} > R(\beta)(= \pi - \frac{e}{\beta\delta}$ as defined by equation (8)), the agent never invests. Indeed, the bank always offers $R > \bar{R}$ in that case. Suppose that $\bar{R} \leq R(\beta)$. For a given R^*, denote by $\bar{R}_1$ and $\bar{R}_2 (> \bar{R}_1)$ the values such that

$$R^* = \frac{\bar{R}_1}{E[p]} = \frac{\bar{R}_2}{E[p \mid p > p_2(R^*)]}.$$

- $\bar{R} < \bar{R}_1 \Leftrightarrow R_N < R^*$. Given Bertrand competition, $R = R^*$ cannot be the equilibrium interest factor since it would imply benefits for banks even if no agent learns p. For all $R < R^*$ agents strictly prefer not to learn p, so the competitive equilibrium is $R = R_N$.
- $\bar{R} > \bar{R}_2 \Leftrightarrow R_L > R^*$. Then, $R = R^*$ cannot be the equilibrium interest factor since it would imply losses for banks even if all agents learn p. For all $R > R^*$ agents strictly prefer to learn p, so the competitive equilibrium is $R = R_L$.
- $\bar{R}_1 < \bar{R} < \bar{R}_2 \Leftrightarrow R_L < R^* < R_N$. In this case, $R = R^*$ is the competitive interest factor if and only if

$$[\alpha(\bar{R})E[p \mid p > p_2(R^*)] + (1 - \alpha(\bar{R}))E[p]]R^* = \bar{R}. \tag{12}$$

But by definition of R^*, agents are indifferent between learning and not. Hence, for each $\bar{R} \in (\bar{R}_1, \bar{R}_2)$, there exists a value $\alpha(\bar{R}) \in (0, 1)$ that satisfies (12). □

Proof of Proposition 2. Given $\bar{R}$, denote by $W_L(\bar{R})$ and $W_N(\bar{R})$ the expected welfare of agents from their self-1 perspective when they all learn p and when none of them does, respectively. We have

$$W_L(\bar{R}) = \beta\delta \int_{p_2(R_L)}^{1} -e + \delta p(\pi - R_L)\, dF(p),$$

$$W_N(\bar{R}) = \beta\delta \int_{0}^{1} -e + \delta p(\pi - R_N)\, dF(p).$$

After some algebra, and given (6) and (7), we get

$$W_L(\bar{R}) - W_N(\bar{R}) \propto e - \delta E[p \mid p < p_2(R_L)]\pi + \delta E[p] R_N.$$

From the definition of R^*, we have

$$p_1(R^*) = E\big[p \mid p < p_2(R^*)\big]$$
$$\Leftrightarrow e = \delta E\big[p \mid p < p_2(R^*)\big]\pi - \delta E\big[p \mid p < p_2(R^*)\big] R^*.$$

Therefore, we overall get

$$W_L(\bar{R}) - W_N(\bar{R}) \propto \pi\big(E\big[p \mid p < p_2(R^*)\big] - E[p \mid p < p_2(R_L)]\big)$$
$$- \big(E\big[p \mid p < p_2(R^*)\big] R^* - E[p] R_N\big).$$

When $\bar{R} \in [\bar{R}_1, \bar{R}_2)$, then $R_L(\bar{R}) < R^* \leq R_N(\bar{R})$ and, as a result, $W_L(\bar{R}) - W_N(\bar{R}) > 0$. Naturally, this same inequality holds for at least some $\bar{R} < \bar{R}_1$. □

Proof of Proposition 3.

- *Step 1:* Iso-profit curves. Denote $R_u(C)$ and $R_i(C)$ the interest factor functions in the iso-profit curves of an uninformed and an informed agent, respectively. Formally,

  $$G_u(R_u(C), C) = \bar{K} \quad \text{and} \quad G_i(R_i(C), C) = \bar{L},$$

  where $\bar{K}$ and $\bar{L}$ are constants. From (3) and (4), we have

  $$\frac{\partial R_u}{\partial C} = -\frac{\partial G_u}{\partial C} \Big/ \frac{\partial G_u}{\partial R} = -\frac{1 - E[p]}{E[p]},$$

  and

  $$\frac{\partial R_i}{\partial C} = -\frac{\partial G_i}{\partial C} \Big/ \frac{\partial G_i}{\partial R}$$
  $$= -\frac{1 - E[p] - \int_0^{p_2}(1-p)\, dF(p) + (1-p_2)(p_2 - p_1) f(p_2)}{E[p] - \int_0^{p_2} p\, dF(p) + p_2(p_2 - p_1) f(p_2)}.$$

- *Step 2:* Iso-profit curves of banks with informed and uninformed agents. We have

$$\frac{\partial R_N}{\partial C} = -\frac{1 - E[p]}{E[p]},$$

and

$$\frac{\partial R_L}{\partial C} = -\frac{\int_{p_2}^{1}(1-p)\,dF(p) - (R-C)\frac{\partial p_2}{\partial C} f(p_2)(E[p \mid p > p_2] - p_2)}{\int_{p_2}^{1} p\,dF(p) + (R-C)\frac{\partial p_2}{\partial R} f(p_2)(E[p \mid p > p_2] - p_2).}$$

- *Step 3:* Comparison of iso-profit slopes and banks' zero-profit condition.

$$\frac{\partial R^*}{\partial C} - \frac{\partial R_u}{\partial C} \propto -A,$$

where

$$A = f(p_2)(p_2 - p_1)(p_2 - E[p]) + F(p_2)E[p] - \int_0^{p_2} p\,dF(p).$$

In R^*, $A \propto \frac{f(p_2)}{F(p_2)}(p_2 - p_1)(p_2 - E[p]) + E[p] - p_1 = k(E[p])$. A is increasing in $E(p)$ and is positive when $E(p) = p_2$. Therefore, for all $p_2 > E(p)$, $A > 0$. Then, $\frac{\partial R^*}{\partial C} - \frac{\partial R_u}{\partial C} < 0$. In the same lines,

$$\frac{\partial R^*}{\partial C} - \frac{\partial R_i}{\partial C} \propto -A \quad \text{and} \quad \frac{\partial R_u}{\partial C} - \frac{\partial R_i}{\partial C} \propto -A.$$

As a consequence,

$$-\frac{\partial R^*}{\partial C} > -\frac{\partial R_u}{\partial C} > -\frac{\partial R_i}{\partial C}. \tag{13}$$

Also, $\frac{\partial R_u}{\partial C} = \frac{\partial R_N}{\partial C} < \frac{\partial R_L}{\partial C}$. Moreover, it is easy to check that $R_L(\bar{R}) = R_N(\bar{R}) = \bar{R}$. Lastly,

$$-\frac{\partial R_i}{\partial C} > \frac{\int_{p_2}^{1}(1-p)\,dF(p)}{\int_{p_2}^{1} p\,dF(p)} = -\left.\frac{\partial R_L}{\partial C}\right|_{(R_L(\bar{R}),\bar{R})}. \tag{14}$$

- *Step 4:* Determination of the equilibria. Denote by $\bar{R}_0$ the value such that $R^*(\bar{R}_0) = \bar{R}_0$. Note that, given (13), $\bar{R}_0 < \bar{R}_1$.

  (1) $\bar{R} < \bar{R}_0 \Leftrightarrow g(\bar{R}, \bar{R}; \beta) > 0$. Hence, according to (13), $g(R_N(C), C) > 0$ and $g(R_L(C), C) > 0$ for all $C \in [0, \bar{R}]$. This implies that, in equilibrium, agents will never learn p. Given that $\frac{\partial R_u}{\partial C} = \frac{\partial R_N}{\partial C}$, every combination $(R_N(C), C)$ with $C \in [0, \bar{R}]$ yields 0 profits to banks and belong to the same iso-profit curve $G_u(R_N(C), C; \beta) = \bar{K}$.

(2) $\bar{R}_0 < \bar{R} < \bar{R}_2 \Leftrightarrow$ for each $\bar{R}$, there exists one and only one value $\tilde{C}(\bar{R}) \in (0, \bar{R})$ such that

$$R^*(\tilde{C}(\bar{R})) = R_L(\tilde{C}(\bar{R})).$$

Given (13), the optimal vector (R, C) compatible with no losses for banks implies (i) learning of p; (ii) collateral $\hat{C}(\bar{R}) \in [\tilde{C}(\bar{R}), \bar{R})$; and (iii) interest factor $R_L(\hat{C}(\bar{R}))$. The exact value $\hat{C}$ depends on the sign of $\frac{\partial R_i}{\partial C} - \frac{\partial R_L}{\partial C}$. In any case, given (14), $\hat{C}(\bar{R}) < \bar{R}$. Note that $(R(\tilde{C}(\bar{R})), \tilde{C}(\bar{R}))$ is the competitive pair of interest factor and collateral if and only if $\alpha(\bar{R}) = 1$.

(3) $\bar{R}_2 < \bar{R} \Leftrightarrow g(R_N(C), C; \beta) < 0$ and $g(R_L(C), C; \beta) < 0$ for all $C \in [0, \bar{R}]$ by (13). Hence, in equilibrium, agents always learn p. Again, there is an optimal collateral $\hat{C}(\bar{R}) \in [0, \bar{R})$. □

References

Ainslie, G., 1992, *Picoeconomics*, Cambridge, UK: Cambridge University Press.

Akerlof, G.A., 1991, "Procrastination and Obedience," *American Economic Review*, 81, 1–19.

Battaglini, M., R. Benabou and J. Tirole, 2001, "Self-Control in Peer Groups," mimeo, Princeton University, Princeton, NJ; and Toulouse University, Toulouse, France.

Benabou, R. and J. Tirole, 2002, "Self-Confidence and Personal Motivation," *Quarterly Journal of Economics*, 117(3), 871–915.

Bernardo, A. and I. Welch, 2001, "On the Evolution of Overconfidence and Entrepreneurs," *Journal of Economics and Management Strategy*, 10, 301–330.

Brocas, I. and J.D. Carrillo, 2001, "Rush and Procrastination under Hyperbolic Discounting and Interdependent Activities," *Journal of Risk and Uncertainty*, 22, 141–164.

Brocas, I. and J.D. Carrillo, forthcoming, "A Theory of Haste," *Journal of Economic Behavior and Organization*.

Caillaud, B. and B. Jullien, 2000, "Modelling Time-Inconsistent Preferences," *European Economic Review*, 44, 1116–1124.

Caillaud, B., D. Cohen and B. Jullien, 1999, "Toward a Theory of Self-Restraint," mimeo, Toulouse University, Toulouse, France.

Camerer, C. and D. Lovallo, 1999, "Overconfidence and Excess Entry: An Experimental Approach," *American Economic Review*, 89, 306–318.

Caplin, A. and J. Leahy, forthcoming, "The Supply of Information by a Concerned Expert," *Economic Journal*.

Caplin, A. and J. Leahy, 2001, "Psychological Expected Utility Theory and Anticipatory Feelings," *Quarterly Journal of Economics*, 116, 55–79.

Carrillo, J.D. and T. Mariotti, 2000, "Strategic Ignorance as a Self-Disciplining Device," *Review of Economic Studies*, 67, 529–544.

Cooper, A., C. Woo and W. Dunkelberg, 1988, "Entrepreneurs' Perceived Chances for Success," *Journal of Business Venturing*, 3, 97–108.

Crémer, J., F. Khalil and J.C. Rochet, 1998, "Strategic Information Gathering before a Contract Is Offered," *Journal of Economic Theory*, 81(1), 163–200.

Daly, M., 1990, "The 1980s—A Decade of Growth in Enterprise—Data on VAT Registrations and Deregistrations," *The Employment Gazette*, 98(November), 533–565.

DeBondt, W.F. and R.H. Thaler, 1995, "Financial Decision-Making in Markets and Firms: A Behavioral Perspective," in R. Jarrow et al. eds., *Handbook in Operation Research and Management*, Amsterdam, Holland: Elsevier Science, 385–410.

Frederick, S., G. Loewenstein and T. O'Donoghue, 2002, "Time Discounting and Time Preference: A Critical Review," *Journal of Economic Literature*, 40, 351–401.

Gul, F. and W. Pesendorfer, 2001, "Temptation and Self-Control," *Econometrica*, 69, 1403–1435.

Harris, C. and D. Laibson, 2003, "Hyperbolic Discounting and Consumption," *Proceedings of the Eighth World Congress of the Econometric Society*, 1, 258–297.

Heaton, J.B., 2002, "Managerial Optimism and Corporate Finance," *Financial Management*, 31, 33–45.

Jovanovic, B. and D. Stolyarov, 2002, "Technology Adoption and Commitments: The Welfare Costs of industrialization Revisited," mimeo, New York University, New York, NY.

Keynes, J.M., 1936, *The General Theory of Employment, Interest, and Money*, London: MacMillan St. Martin's Press.

Krusell, P. and A.A. Smith Jr., 2003, "Consumption-Savings Decisions with Quasi-Geometric Discounting," *Econometrica*, 71, 365–375.

Laibson, D.I., 1997, "Golden Eggs and Hyperbolic Discounting," *Quarterly Journal of Economics*, 112, 443–477.

Larwood, L. and W. Whittaker, 1977, "Managerial Myopia: Self-Serving Biases in Organizational Planning," *Journal of Applied Psychology*, 62, 194–198.

Loewenstein, G. and D. Prelec, 1992, "Anomalies in Intertemporal Choice: Evidence and an Interpretation," *Quarterly Journal of Economics*, 107, 573–598.

Manove, M., 1997, "Entrepreneurs, Optimism, and the Competitive Edge," mimeo, Boston University, Boston, Massachusetts.

Manove, M. and A.J. Padilla, 1999, "Banking (Conservatively) with Optimists," *RAND Journal of Economics*, 30, 324–350.

O'Donoghue, T. and M. Rabin, 1999, "Incentives for Procrastinators," *Quarterly Journal of Economics*, 114(3), 769–816.

Phelps, E.S. and R.A. Pollak, 1968, "On Second-Best National Saving and Game-Theoretic Growth," *Review of Economic Studies*, 35, 185–199.

Read, D., 2001, "Is Time-Discounting Hyperbolic or Subadditive?" *Journal of Risk and Uncertainty*, 23(1), 5–32.

Roll, R., 1986, "The Hubris Hypothesis of Corporate Takeovers," *Journal of Business*, 59, 197–216.

Rubinstein, A., 2003, "Is It "Economics and Psychology"?: The Case of Hyperbolic Discounting," *International Economic Review*, 44, 1207–1216.

Hibbard, G.R., ed., 1998, *Hamlet*, New York: Oxford University Press.

Shapiro, D. and R. Khemani, 1987, "The Determinants of Entry and Exit Reconsidered," *International Journal of Industrial Organization*, 5(1), 15–26.

Stiglitz, J. and A. Weiss, 1981, "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, 71, 393–410.

Strotz, R.H., 1956, "Myopia and Inconsistency in Dynamic Utility Maximisation," *Review of Economic Studies*, 23, 166–180.